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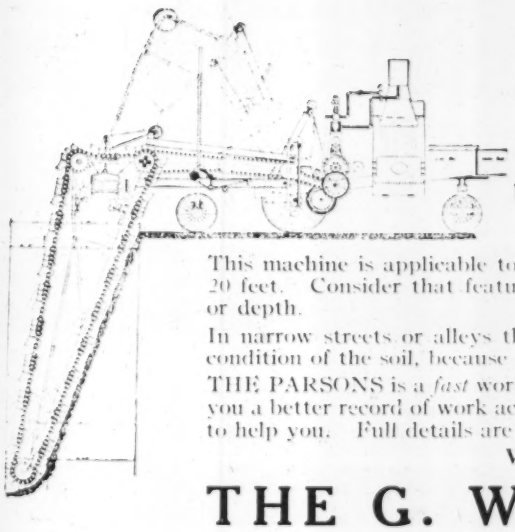

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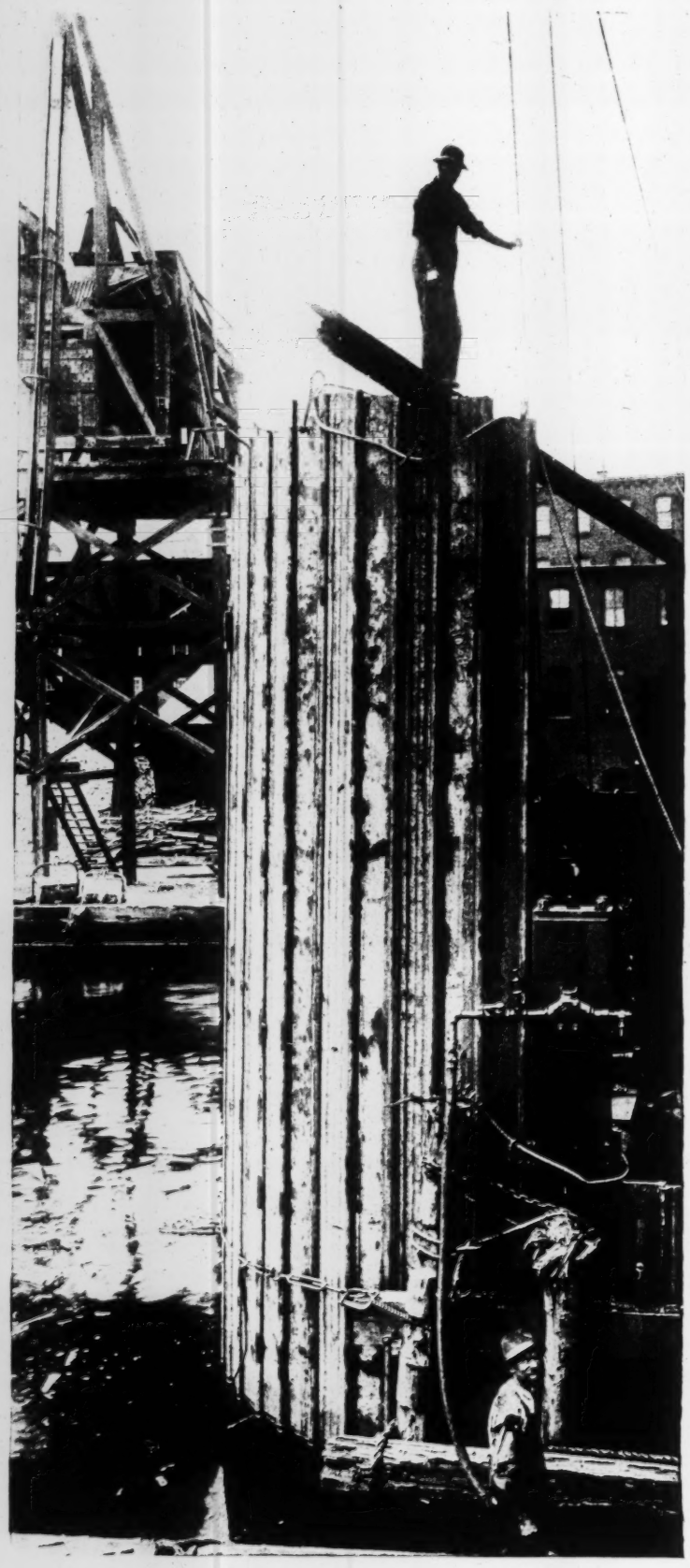

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Engineering News

CHARLES WHITING BAKER, *Editor*

Subscriptions payable in advance, $5.00 a year for 52 numbers, including postage in the United States, Mexico, Cuba, Porto Rico, Hawaii, or the Philippines, $7.00 in Canada.

Published Weekly By HILL PUBLISHING COMPANY

505 Pearl Street, New York, N. Y.

JOHN A. HILL, Pres. ROB'T MCKEAN, Sec'y.

Cable Address: "ENGNEWS"

To foreign countries, including postage, $9.00 or its equivalent, 38 shillings: 38 marks: or 45 francs. Notice to discontinue should be written to the New York Office in every instance. Advertising copy should reach New York Office by Thursday of week before date of issue. Entered at New York Post-office as mail matter of the second class.

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Engineering News

VOLUME 69 MAY 1, 1913 NUMBER 18

The New Grand Central Terminal Station in New York City: An Underground Double-Deck Terminal

About the time the New York Central & Hudson River R.R. Co. was directed by the Legislature of the State of New York to introduce electric operation on its New York City terminal lines, in 1903, the railway company began also making plans for radical reconstruction and enlargement of its New York terminal station. The existing station and terminal yard were too small, in spite of recent modifications and enlargement. The site was hemmed in by buildings on all sides in such a way as to preclude further enlargement except by purchase of more ground at great expense; and if this were done the situation would naturally call for a complete replanning of trackage and facilities. With electric operation—that is to say on a completely modernized basis which provided for satisfactory operating conditions far into the future—it was also desirable to modernize the terminal plant and provide for more than the immediate year or two ahead.

The great increase of operating capacity which might be secured under electric operation could not be realized in the old terminal plant, whereas by a new, larger terminal the full benefit in this direction might be attained. At the same time, enlargement of the terminal would also take care of the equally important matter of increasing the capacity of the four-track approach (tunnel and viaduct) extending north from the terminal yard about four miles to near the Harlem River; for, under the existing conditions the capacity of the tunnel, in itself hardly more than enough, was further reduced by frequent delays to trains in the tunnel caused by the

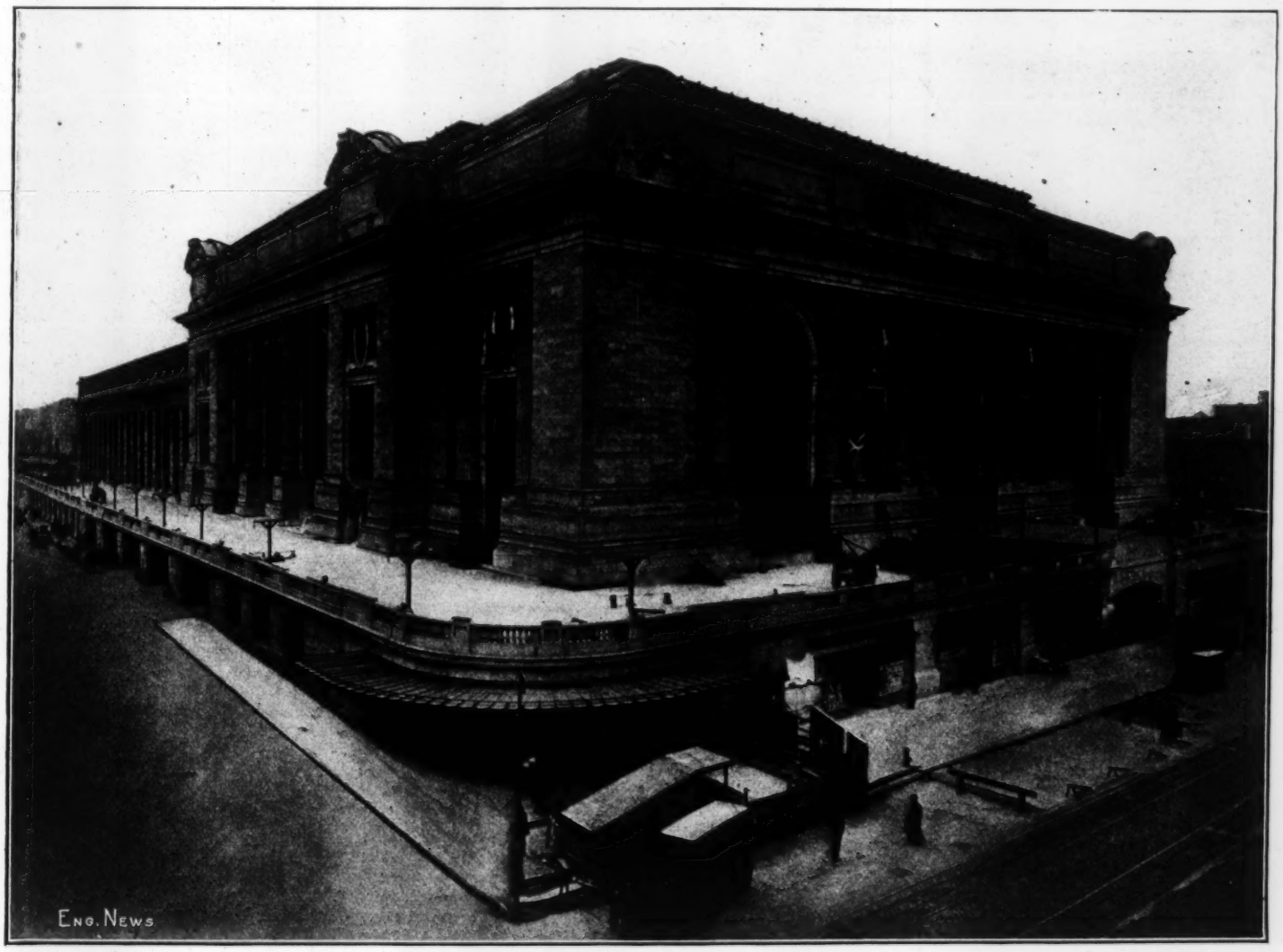


FIG. 1. GENERAL VIEW OF NEW GRAND CENTRAL TERMINAL STATION, NEW YORK CITY, LOOKING NORTH

(Terminus of the New York Central & Hudson River R.R. and the New York, New Haven & Hartford Ry. See Fig. 6 for appearance when completed. The bridge connecting the elevated roadway around the station building with Park Ave. at 41st St. is shortly to be built by the city.)

inadequate entrance and storage facilities of the terminal yard.

The study of preliminary plans for reconstruction of the terminal was soon followed by start on actual construction. Widening of the throat of the yard and of the approach to the tunnel was begun in 1903. The main portion of the yard was taken in hand in 1907, by which time the plans for the whole improvement were in nearly final form. The six years from 1907 to the present time have seen the work brought to substantial completion; on Feb. 2, 1913, the new main passenger station was opened to traffic. The remaining construction, including the Incoming Station building, is likely to continue dur-

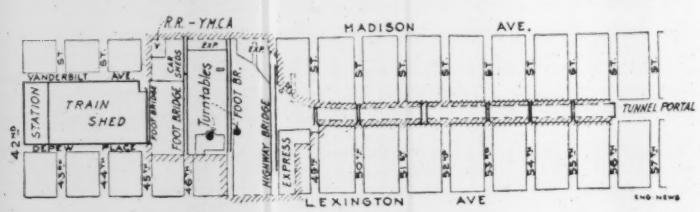


FIG. 2. TERMINAL, 1900-1905

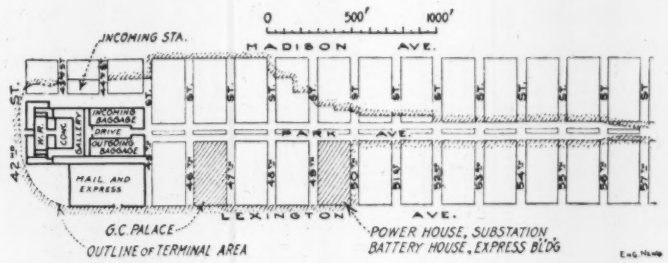


FIG. 3. NEW TERMINAL, 1913

FIGS. 2 AND 3. SKETCH PLANS OF SITE, GRAND CENTRAL TERMINAL, OLD AND NEW

ing the present year and the next, so that by the end of 1914 the entire terminal plant will be in service, after eleven years of building.

NEW FEATURES

The radically new elements of the terminal are:

1. Double-deck arrangement of tracks, both levels being below ground.
2. Separation of suburban from through-train traffic by placing them on separate levels.
3. Separation of incoming from departing traffic, by provision of a separate building for incoming traffic, straddling the arrival tracks, which are at the west edge of the terminal yards.
4. Provision of turning loops for both suburban and through trains, which will eliminate a large proportion of the shifting movements.
5. Utilization of nearly the whole yard space for building over, together with restoration of the full network of streets over the site except the area occupied by the main station and office-building.

Not all these features were contained in the plans first developed, but they resulted during the gradual process of change and improvement of plans.*

RELATION TO ELECTRIC OPERATION

The substitution of electric traction for steam operation in the terminal zones of the New York Central & Hudson River R.R.† and the New York, New Haven & Hartford R.R.‡ was completed in 1906, and since that time all trains for a distance of 10 to 30 miles out of New York on both railways have been hauled by electric locomotives or operated as multiple-unit electric trains (suburban service). This change of method of operation laid the foundation for great future changes in the character and amount of traffic, and in particular made available a great increase in traffic capacity of the

*This evolution went on throughout the construction period. As late as 1911, substantial revisions of the plans were made. The most important revision, that on which the main yard work was based, is that of 1907. It represented a great increase in yard space and a complete change in the track layout, as compared with the 1905 plan. An article describing the electric-traction equipment of the New York terminal division. "Engineering News," Nov. 16, 1905, pp. 499-509, showed a track plan of the new terminal as then designed. This may be compared with the plan shown in the present article, representing the work as built.

†"Engineering News," Nov. 16, 1905, p. 499.

‡"Engineering News," Mar. 22, 1906, p. 342; Sept. 5, 1907, p. 239; Dec. 31, 1908, p. 733.

STATISTICS OF OLD AND NEW GRAND CENTRAL TERMINAL

	Before improvement	After improvement				Increase	
		Suburban sta.	Express level	Street level and above	Total	Amount	Percent.
Area of terminal, acres	23.24	32.88	44.95		77.83	54.59	235
Miles of track							
Platform	2.91	2.23	5.05		7.28	4.37	150
Storage	1.54	3.94	2.81		6.75	5.21	338
Express	0.35		0.84		0.84	0.49	140
Mail	0.16		0.42		0.42	0.26	163
Running, etc.	5.88	7.95	9.82		17.77	11.89	202
Total	10.84	14.12	18.94		33.06	22.22	205
Car capacity of tracks							
Platform	214	143	297		440	226	106
Storage	640*	345	184		529	Decrease111	17
Express	26		62		62	36	139
Mail	11		26		26	15	136
Total	891*	488	569		1057	166	19
No. of platform tracks	19	17	33		50	31	163
Areas:							
Building, acres	5.90			10.09	10.09	4.19	71
Offices, sq.ft.	129,500			475,000	475,000	345,500	266
Post-office, sq.ft.	33,000			127,050	127,050	94,050	285
Waiting rooms, sq.ft.	12,443	1,920	17,156†		19,076†	6,633	53
Retiring and toilet rooms, sq.ft.	1,391	4,699	10,092		14,791	13,400	963
Restaurant, etc., sq.ft.	2,647	21,909				19,262	728
Ticket offices, sq.ft.	1,444	2,088	2,516		4,604	3,160	219
Parcel stand, sq.ft.	507	1,592	1,750		3,342	2,835	559
Baggage rooms, sq.ft.	33,315	1,350	2,000	67,376	70,726	37,411	112
Concourses, sq.ft.	14,814	35,898	46,224		82,122	67,308	454
Ticket lobby, sq.ft.	1,490						
Cab stands, sq.ft.	2,952		18,315	40,312	58,627	55,675	1886
Street viaducts, sq.ft.				754,459	754,459	754,459	

* Includes 525 car capacity of Mott Haven yard.
† Express level includes 3532 sq.ft. in Incoming Station.

railways. To utilize this, and especially to develop it properly by the greater frequency of service possible under electric operation, required a very much larger terminal than the old one to provide for both the increased amount and the changed character of traffic. The Grand Central Terminal site did not afford space for the necessary expansion *on one floor*. The double-deck scheme, which of course is possible only with electric operation, solves the problem. It incidentally gives the

Under these circumstances the terminal yard is radically transformed from its usual outdoor character, and becomes simply a special occupancy of two basement floors of a building.

Relation to Prior Conditions

The New York terminus of the New York Central and predecessor lines moved northerly with the gradual growth of the city, beginning some 80 years ago when the

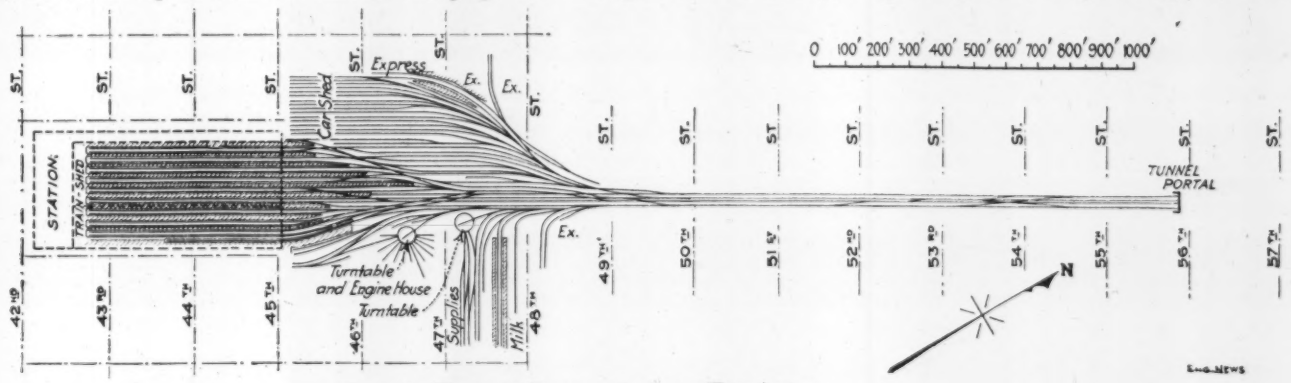


Fig. 4. Track Plan of Old Terminal

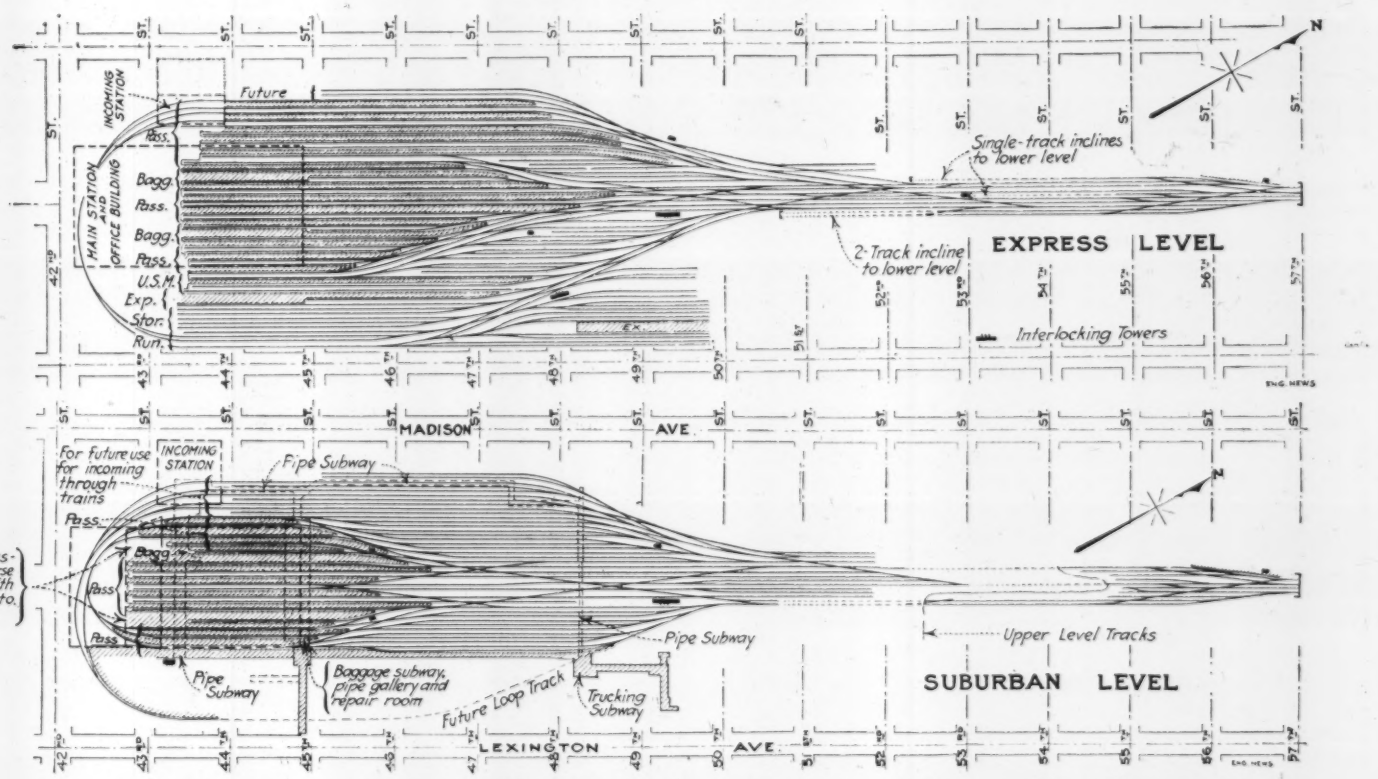


Fig. 5. Track Plans of Express (Upper) and Suburban (Lower) Levels, New Terminal

Figs. 4 and 5. Condensed Track Plans of Grand Central Terminal, Old and New

very great advantage of separating the suburban from the through traffic, an advantage both to the passenger and to the railway company. Loop tracks for turning trains develop this scheme to its fullest extent by increasing the effective capacity of the terminal tracks.

A steam-railway terminal is necessarily of outdoor character, as the locomotive smoke and gases must have free escape. Electric operation allows of complete covering. In the New York Central terminal this possibility is fully utilized in the lower level, and (at present) partly in the upper level. When the open areas between streets are fully covered with commercial buildinges (as is expected to be the case in a few years) the upper level also will be completely inclosed.

terminus was located about three miles south of the present location. The station was moved north to 26th St. (the site of the present Madison Square Garden) in the fifties of the last century, although after 1857 steam operation below 42nd St. was prohibited, and cars were hauled south of there by horses. In 1871 the station at 42nd St. was built. It was enlarged and altered repeatedly, and especially in 1898 was considerably improved by increasing the trackage and by raising the station building three stories.

The 42nd St. station and terminal made a very serious break in the city's street system in an important region, as illustrated best by the fact that prior to the present improvements there were but two street-crossings for

vehicles over the railway terminal tracks between 42nd and 56th Sts., three-quarters of a mile. The seriousness of this condition and the past history of the northward movement of the railway terminal doubtless helped to impress the directors of the railway company with the need of such a reconstruction of the terminal as would be proof against the growth of hostile public sentiment, which might in time compel a further northward removal of the terminal to suit the needs and convenience of the city. At any rate, the result of the work is such as would have been produced under the stimulus of a motive of this kind.

Traffic

The traffic of the Grand Central station has in recent years amounted to some 400 trains per day, i.e., about 200 each way. The station serves two railways, connecting points between Boston and St. Louis. Both lines have a fairly heavy suburban traffic. The traffic of the terminal in 1900, 1905 and 1910, was about as follows:

Total for year	1900	1905	1910
Trains	106,000	128,000	130,000
Cars	575,000	695,000	755,000
Passengers	13,600,000	18,100,000	20,150,000

The six-mile section of road immediately north of the terminal is a four-track line in tunnel and on elevated structure; beyond this the two railways total 8 to 12 tracks. The railway lines can readily bring in more trains than the four-track section can accommodate, unless the movement of trains in the tunnel is regulated with great precision and is free from all delays and interruptions. The old terminal yard was too small to insure this condition, as its ladder tracks could not always be cleared rapidly enough for incoming trains, so that trains frequently were held in the tunnel and thus the capacity of this narrow part of the line was throttled.

In the period of steam operation, i.e., prior to 1906, there was an unusually large proportion of waste or idle movements of locomotives and trains in the terminal and through the tunnel, partly because the engines of incoming trains had to be turned before they could take their trains out and partly because the lack of storage space in the terminal yard made it necessary to return empty trains and light engines to the Mott Haven yards. These conditions were much ameliorated by the introduction of electric motive power. The natural growth of traffic soon neutralized this improvement, however.

The new terminal, with greatly increased area and extensive storage tracks, reduces the idle movements considerably and (by eliminating all holding of trains in the tunnel) allows the full capacity of the tunnel to be developed. Even so the capacity of the tunnel will be much less than that of the terminal, and the latter in fact will be able to take care of a possible future two-track line connecting with the New York Central's double-track branch now extending along the east bank of the Hudson River from Spuyten Duyvil down to 30th St.

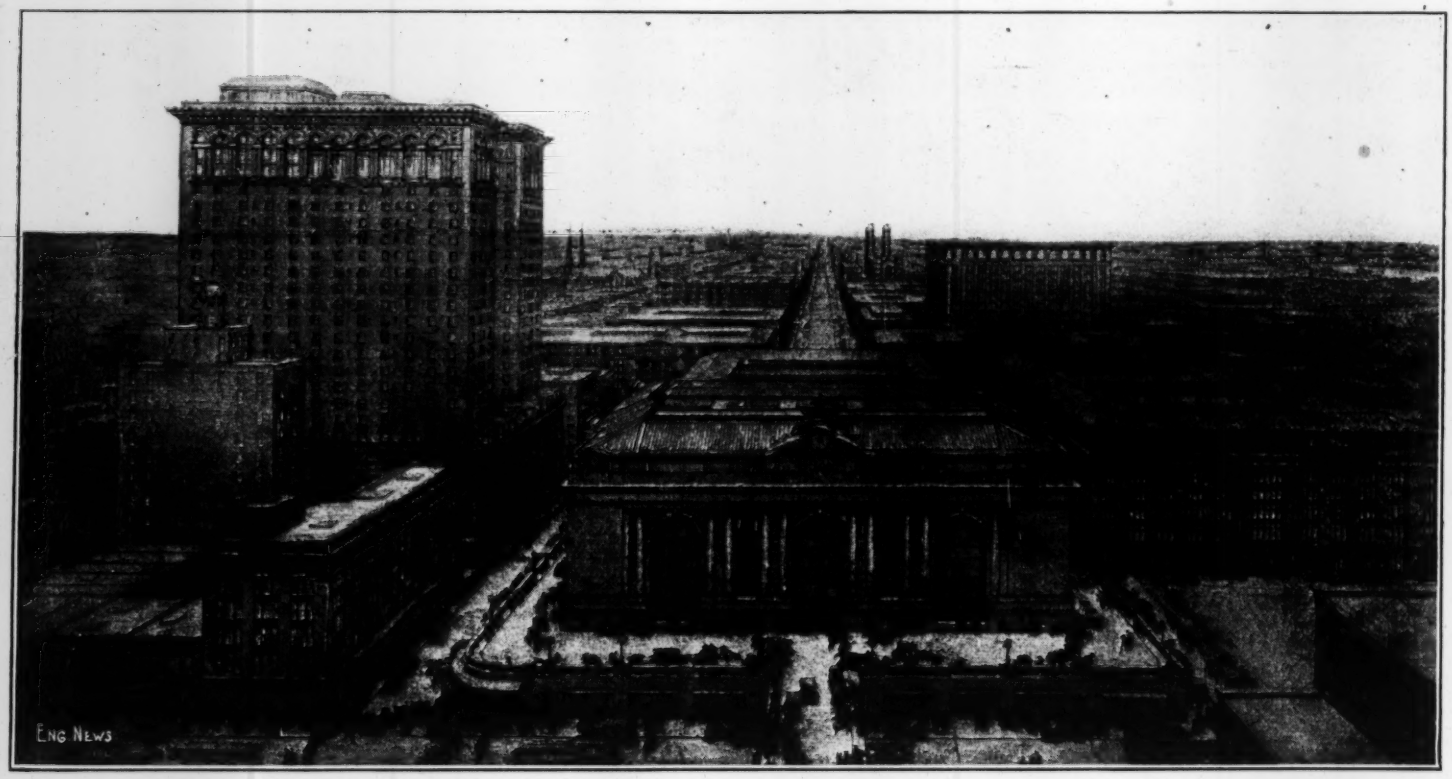


Fig. 6. The New Grand Central Terminal As It Will Appear When Completed

(Buildings are shown on the block areas over the yard. The tall building at the left, the Biltmore Hotel, containing the Incoming Station in its lower part, is now being erected. The tall building at the right is the new Grand Central Palace, and behind it at 50th St. is the Service Plant, whose brick smokestacks are surrounded with steel tower framing for architectural effect.)

The New Terminal

Figs. 2 and 3 show comparative sketch plans of the terminal site under the old and the new conditions. The principal buildings or parts of the site used for various terminal or auxiliary purposes are noted in these sketches. Attention is drawn to the complete street connection over the new terminal, due to the underground location as already noted. The extent to which the old terminal

interrupted the east-west lines of communication (Fig. 2) will be understood better upon considering that, since the tracks were nearly at street grade, all bridges over the tracks had to rise by steep inclines or stairs.

That the new site is much larger than the old (apart from the matter of double-decking) is not so readily seen on comparing Figs. 2 and 3 as on noting the figures:

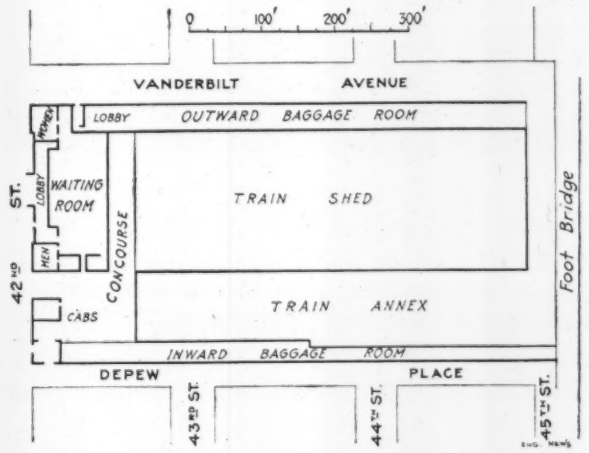
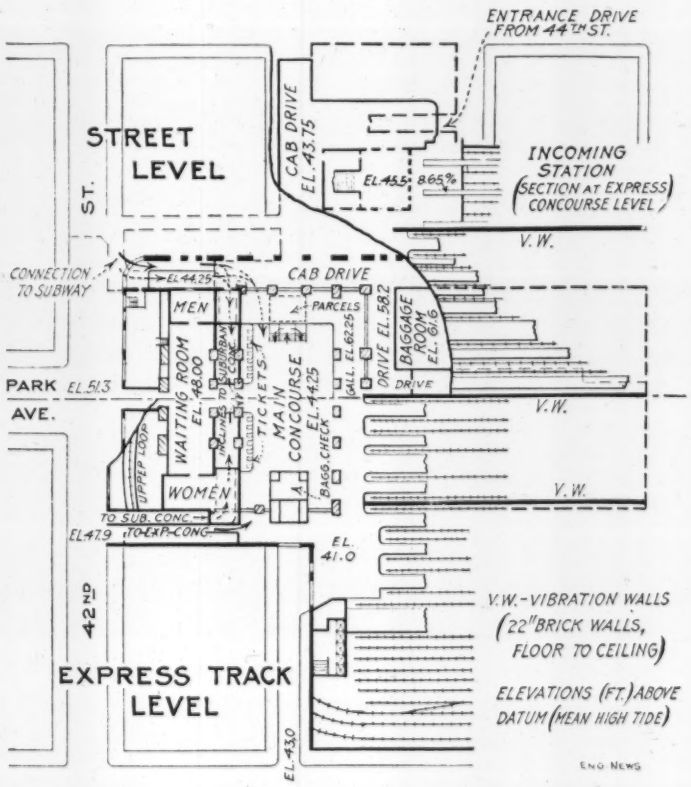


FIG. 7. STATION AFTER 1900 RECONSTRUCTION



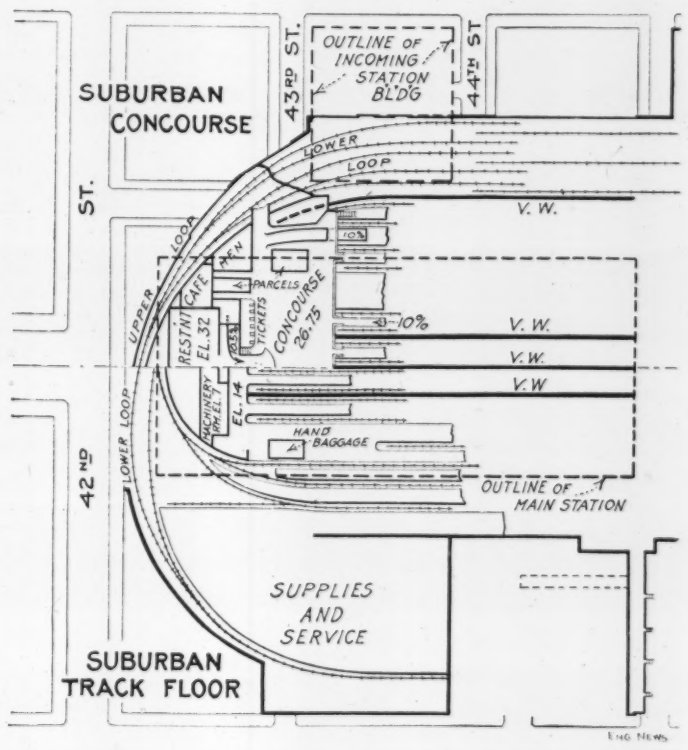


FIG. 8. NEW MAIN AND INCOMING STATIONS

FIGS. 7 AND 8. DIAGRAM PLANS OF OLD AND NEW PASSENGER STATIONS, GRAND CENTRAL TERMINAL

From 42nd St. to tunnel portal, area actually occupied by yard, station and facilities, 47 acres in the present terminal against 23¼ acres in the old; passenger platform track capacity, 440 cars against 214; storage track capacity, 529 against 115. The increase is due to widening of the yard (chiefly on the east side), widening of the approach to the full width of Park Ave., and elimination of waste space and facilities now unnecessary, besides the double-decking.

The buildings of the new terminal include: Main Station (maximum height 6 stories), the northerly half of which is used as office-building above the first story, and houses part of the railway offices; Incoming station (under Biltmore Hotel, 43d to 44th Sts., Vanderbilt Ave. to Madison Ave.); Postoffice and office-building, which also provides accommodation for the American Express Co.; Substation for traction current, transforming the incoming 11,000-volt current to 660-volt direct current for third-rail supply and 300-volt current for signal supply; Storage-battery house for traction current; Service Plant, supplying steam for heating and electric current for lighting the entire terminal area.

A wareroom and exhibit building (corresponding to the old Grand Central Palace, but several blocks further north) has been built on the Lexington Ave. frontage of the terminal by the railway company. This building, and the Biltmore Hotel, the Adams Express Co. building, the Railroad Y. M. C. A., and the United Cigar Stores building (42d St. and Vanderbilt Ave.), are the only buildings of commercial nature which the railway company has erected on the terminal area at present.

Ultimately all spaces between streets are to be used for commercial or private buildings, the railway company probably leasing the area with restrictions on height of building and column locations. The architectural scheme of the terminal contemplates that the buildings between Depew Place and Vanderbilt Ave. shall be limited to six stories in height (except for a possible future building around the station concourse), and those outside this width to twenty stories. The steel framing of the track levels is designed for such building loads.*

TERMINAL YARD

Comparative track plans of the old and the new terminal are shown in Figs. 4 and 5. The latter is double, representing separately the upper level (for through trains) and the lower level (for suburban trains). The northern end of the yard is now at 57th St., the south

*Except that along the west side of the terminal independent building columns were provided wherever possible, i.e., columns passing through the track framing and independent of it.

portal of the Park Ave. tunnel (formerly at 56th St.), and the total length of the terminal from this point south to 42nd St. is about ¾ mi. Between 52nd and 54th Sts. are located three track-inclines (one double-track, two single-track) with four tracks leading down to the lower level. The gradients of these inclines are 2.7% and 3.0%. Just south of the inclines the principal ladder tracks begin, commanding the whole width of the terminal. The length available south of the ladders is not sufficient for straight platforms of the desired length at the extreme east and west edges of the yard, and some of the platforms extend well out along the curves.

The track layout was made the primary feature in

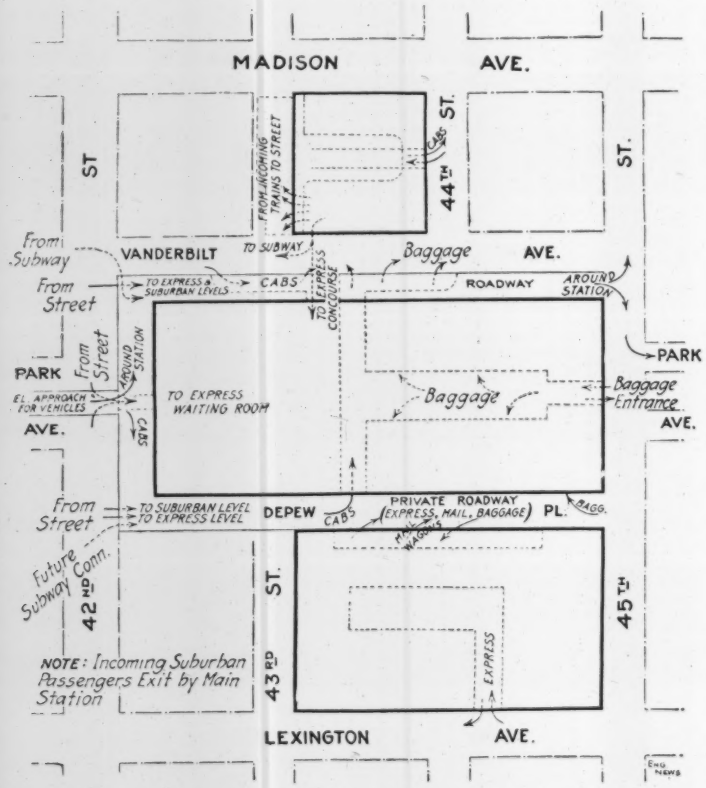


FIG. 9. SKETCH INDICATING PRINCIPAL TRAFFIC CONNECTIONS OF NEW GRAND CENTRAL STATION

the design of the terminal. Column locations, property limitations, etc., were not considered in making the layout, but the tracks were arranged to give the best terminal which the general nature of the site and the operating conditions permitted.

The westerly five tracks on each level are for incoming through trains. The platforms here are among the longest platforms in the terminal, one being 1525 ft. long. On the suburban level these arrival platforms have not yet been built, intermediate tracks being laid in their place, as the upper-level arrival tracks are adequate for the present through-train service. The suburban business does not require the use of the long platforms.

The arrival tracks come directly under the Incoming Station. They are connected by spiraled semicircular loop tracks with the easterly edge of the yard, so that incoming trains can, after unloading, be brought around the loop and set either in the storage yard or on departure tracks. That portion of the lower-level loop which is intended to be used by through trains has not been completed at present, as part of it must be tunneled under the express-level tracks (built previously), and it is not desired to do this until the use of the lower-level arrival tracks becomes necessary.

The platform tracks of both floors are generally arranged in pairs between platforms. A few baggage tracks are placed singly between platforms. On the suburban level several loop tracks are provided connecting the three westerly with the three easterly platform tracks, thus permitting some of the incoming suburban trains (multiple-unit equipment) to reach a different track for departure without backing through the yard ladders. These loop tracks are inside the larger loop of the five main arrival tracks intended for through-train service.

Some figures as to the tracks are given in the adjoining table "Grand Central Terminal Statistics." A similar table was given in our issue of Nov. 16, 1905, p. 503, which gave data for the terminal plans as developed at that time; comparison of the two tables indicates the growth of the scheme.

Briefly summarized, the upper level contains 21 pas-

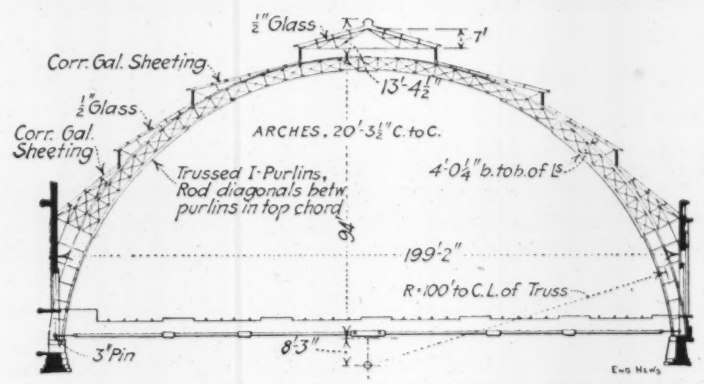


FIG. 10. TRAINSHED OF THE OLD GRAND CENTRAL TERMINAL

(Compare with lower drawing in Fig. 11, which is a cross-section through the train rooms of the new station.)

senger-train tracks, 6 baggage tracks, 2 mail tracks, 3 express tracks, 5 storage tracks, and 4 running tracks, a total of 41 tracks. The lower level contains 13 passenger tracks, 4 baggage tracks, and 8 storage tracks, a total of 25 tracks.

The platforms (see Figs. 12 and 13) are 14 ft. 4 in. to 27½ ft. wide, and have their floor 4 ft. to 4 ft. 3 in. (baggage platforms) above top of rail. They follow the grade of the tracks longitudinally. All platforms are hollow reinforced-concrete structures comprising side walls and a floor slab; the hollow space below is in most cases occupied by ducts, piping, etc. Where a platform comes over a longitudinal expansion-joint of the steel floor-framing, one of the side walls is made with a horizontal sliding joint just above track level; a steel plate forms one face of this joint. These joints are said to be working satisfactorily.

The platforms are connected to the concourse floors by inclines generally of 10% slope. The suburban concourse, located above track clearance height on account of the loop tracks, has very long inclines, while those of the express-level concourse are short (see longitudinal section, Fig. 11). Inclines are used quite generally throughout the station on the lines of movement of passengers, and stairs are largely eliminated.

TRACK CONSTRUCTION—The suburban tracks rest on the rock bottom of the excavation. The upper-level tracks rest on the steel-frame concrete-filled roof of the

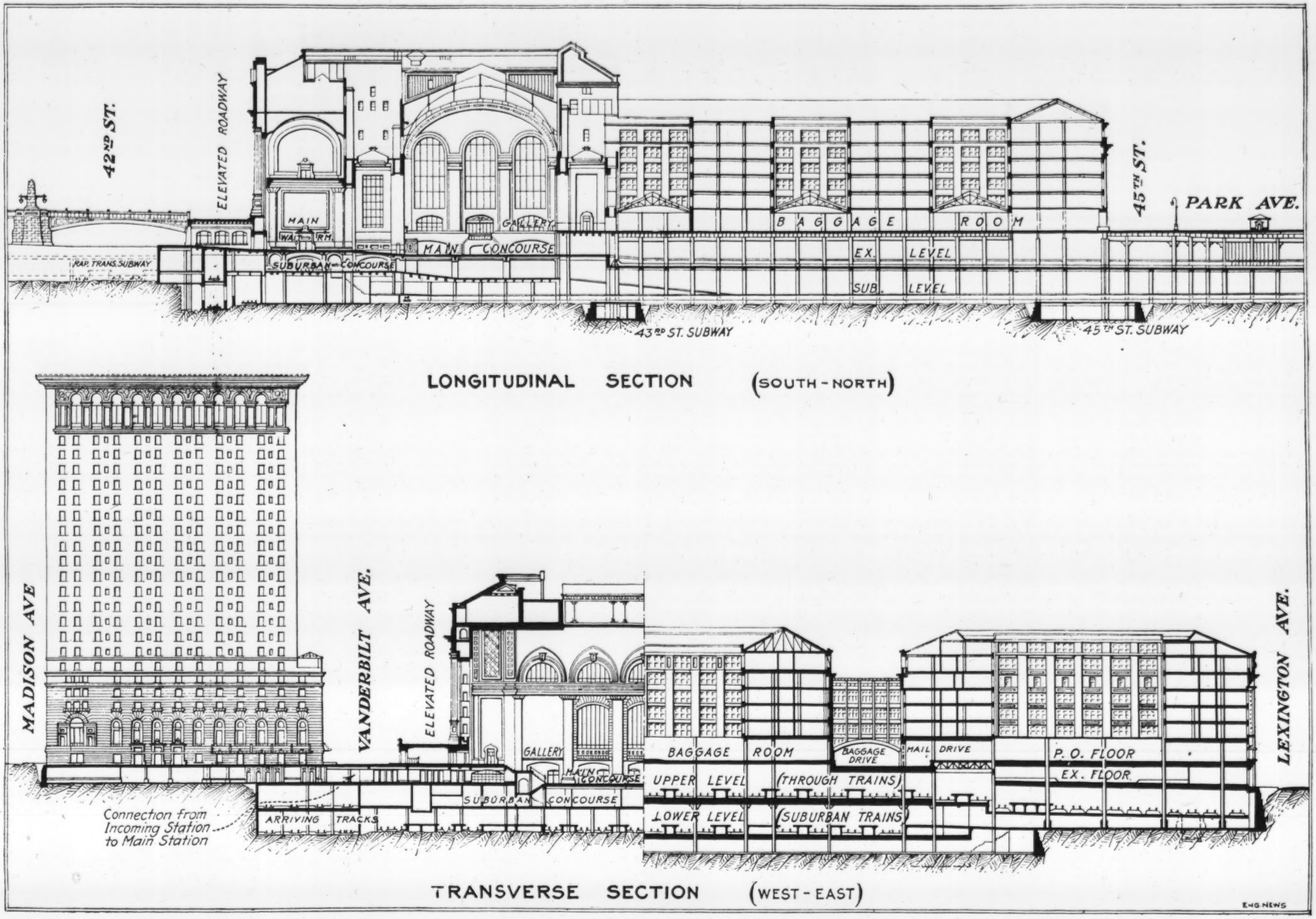


FIG. 11. SECTIONS THROUGH PLATFORM TRACK PORTION AND CONCOURSE OF NEW GRAND CENTRAL TERMINAL

suburban level, except where the upper level extends beyond the limits of the lower level.

The roadbed of all platform tracks is of concrete with wood-block supports for the rails and screw-spike fastening, while elsewhere the roadbed is of conventional stone-ballasted crosstie construction. The blocks are creosoted yellow pine (in the loop tracks creosoted white oak). The concrete roadbed is shown in Fig. 13. It was constructed by assembling rails and blocks as a finished track, supported by suspending from timbers resting on the platforms, and then pouring the concrete under and around the blocks. The taper in width of the blocks permits their removal and replacement; the space between the blocks of the two rails is ample for sliding a block out from under its rail. The blocks for supporting the third-rail are independent of the regular blocks, but continue on the same taper, and can therefore be removed after removal of the latter.

To test the service given by the concrete roadbed in the yard tracks, part of one ladder track and a turnout will be laid with this roadbed instead of ballast roadbed.

The rails are of the New York Central 105-lb.-per-yd. section, and, except on the loop tracks, are of normal 0.65-carbon composition, but the frogs, switches, running and guard rails of the loops are of rolled manganese-steel. All other frogs and switch points are faced with manganese-steel. Guard rails are used at turnouts and on the loops, and on the latter the construction is continued through the switches by using housed-in switch points.

The turnouts in the main yard are generally of about 600-ft. radius; No. 8 frogs are used, except in the earliest part of the new yard, where No. 6½ frogs were put in. The loops are of course much sharper than the turnouts; they are spiraled.

Where tracks cross transverse expansion-joints in the steel floor-framing, expansion splices are used in the rail. One of these is shown in Fig. 12.

Station Building

The new Grand Central Station occupies the same site as the previous one, 42nd to 45th Sts. and Depew Place to Vanderbilt Ave., and has an annex west of Vanderbilt Ave., in part of the ground floor and basement floor of the Biltmore Hotel. This annex is the Incoming Station. Though continuous with the main station on the three underground levels, it brings about an effective separation of the streams of station traffic pertaining to departing trains and incoming trains respectively. It provides facilities separate from those of the main station as follows: Waiting-room, train platforms and concourse, cab stand, passageways, exits, and passages to rapid-transit subway, besides giving the incoming passenger direct access to Madison Ave., a street not used by the traffic of the main station.

The dimensions of the main station and office-building are 301x722 ft. in the first story, and 290x670 ft. above. The south, east and west faces are set back about 50 ft. from the building line above the second floor, making a terrace which is occupied by an elevated roadway.

The elevated roadway is an important item of the entire scheme, as it virtually makes Fourth Ave. (Park Ave.) continuous through the station site by bypassing it around the west side of the building, whereas the old station completely interrupted Park Ave. from 42nd to 48th Sts. The roadway leads to the transverse viaduct carrying 45th St. across the yard at the north end of the station. North of this point Park Ave. and all cross-streets extend over the yard in full width and without detour or interruption. The only gap in the street network, therefore, is the suppression of 43rd and 44th Sts. from Lexington Ave. west to Vanderbilt Ave.

The general nature of the new main station building as an architectural monument may be seen from the view on the first page.* The architect describes the exterior as being an expression of the idea that this station is a gateway, which is given as the reason for the three arch openings in the front of the building. These arches are 33 ft. wide by 60 ft. high in the clear. The building is a steel-frame structure faced with granite and Indiana limestone and finished in the interior in marble, Caen stone, and concrete. Though 125 ft. high, it is essentially a one-story building. The height of the concourse fixes the general height of the building; this in turn determines the height of all future buildings on the width between Vanderbilt Ave. and Depew Place for the entire north-south extent of the terminal, as already noted. The framing around the concourse, however, is designed for future building over.

The outline floor-plans Fig. 8, and the sections Fig. 11, give some idea of the arrangement of the station. The main concourse, of dimensions 120x375 ft. by 125 ft. high in the clear, extends transversely across the station and is the central feature of the building. South of it is a waiting-room with adjoining auxiliary rooms. Ticket offices and all other service provisions are in the concourse. The connection of waiting-rooms to concourse, concourse to track platforms, etc., is made by inclines, the main concourse being about 10 ft. below street level at front or about 20 ft. below street level at rear of the building.

Stairs are eliminated in nearly all cases in the station (so far as passengers are concerned) and inclines are substituted. These vary from 6% to 11.6% in slope. The inclines connecting the concourse floor on express and suburban levels with the track platforms are examples of the use of these inclines; the former handle a few feet difference of elevation, while the suburban-platform inclines descend about 14 ft.

The arrangement of the station with regard to the movement of passengers, baggage, etc., is indicated in the sketch Fig. 9. The design of the station and the arrangement of the different facilities is such as to separate conflicting streams of movement and to make the routing of the passengers or baggage as direct as possible. For the same purpose direct connection by underground passageways will be made from the station to the present rapid-transit subway, the new Broadway-Lexington Ave. subway, the Hudson & Manhattan tunnel extension (if built), and the Belmont tunnel which crosses under the East River to Long Island City, these four structures being at different levels.

Incoming Station

The Incoming Station is relatively simple, consisting merely of a waiting-room over the express tracks and an

*The plans of 1905 were quite different architecturally; see a view of the station then planned, in "Engineering News," Nov. 16, 1905, p. 499.

adjoining cab driveway with an incline to the street. Its waiting-room floor is nearly level with the express concourse of the main station, and directly adjoins and communicates with it under Vanderbilt Ave.

As already noted, this station is located in the Biltmore Hotel, which is being built by the railway company. About a third of the ground-floor area and about two-thirds the basement area of the hotel building are occupied by the station.

Structural Arrangement

The sketches Fig. 11 (cross-sections of the building) and Fig. 12 (a few special plans and sections of framing) show the characteristics of the steel framing which supports the track and buildings.

Generally, the structure consists of a normal grouping of steel columns, main girders, closely spaced secondary beams or girders, and plain concrete floor-arches of short span. However, numerous complications and variations arise from the provision for buildings over the track levels. On the one hand this resulted in very heavy concentrated loads, and on the other hand it required many columns to be supported on girders, since the columns in the suburban story had to be located between the suburban tracks, while those in the express story had to be set between the express tracks, the track layout of the two yards being quite different. Where the columns of a 20-story building are thus supported on girders, remarkably heavy girder construction results.

In the design of the earliest steelwork where buildings cover tracks, viz., in the main station, no attempt was made to keep the building columns independent of the track-floor framing. When the office portion of the building was completed and trains were operating on the girder-supported express level, perceptible vibration developed, and it was subsequently thought well to reduce this disturbance by building several longitudinal walls between columns of the track levels (these walls are marked *VW* in the plans, Fig. 8). In all further steel designing, the principle was followed of keeping *building columns independent of the track-floor framing wherever possible.*

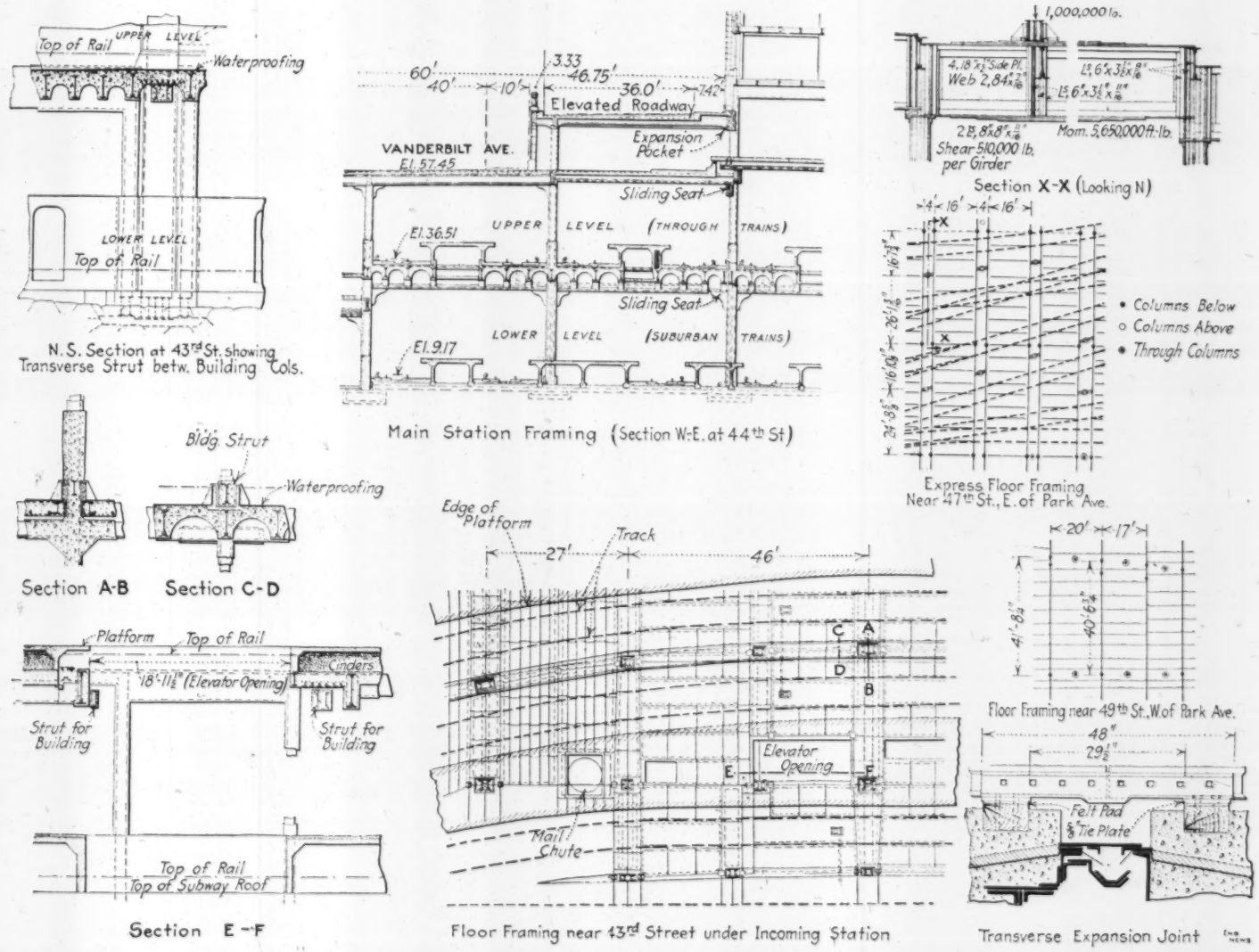


FIG. 12. SKETCHES OF FRAMING IN TRACK LEVELS

The fullest application of this principle was made in the area west of Vanderbilt Ave., which will be occupied by high-class buildings (Biltmore Hotel, now being built, and Yale Club, about to be built; future buildings north of 45th St. are likely to be similar). In Fig. 12 is shown a part plan of the express-floor framing under the southern part of the Biltmore Hotel. All columns are in groups of three; the outer two take the girders of the track floor, while the middle one goes through the floor with clearance, and supports the frame of the building above. For rigidity the building columns are connected by portal-strut beams, either just above or just below the express floor and clear of that floor. Several vertical sections are shown to illustrate the construction further.

A perfected form of this construction is used farther

north in the same strip, as illustrated by a diagrammatic plan from the block between 48th and 49th Sts. Here the building columns are located halfway between the track-floor columns, and thus they do not interfere with normal arrangement of the floor framing. The floor columns in consequence are single instead of double. The

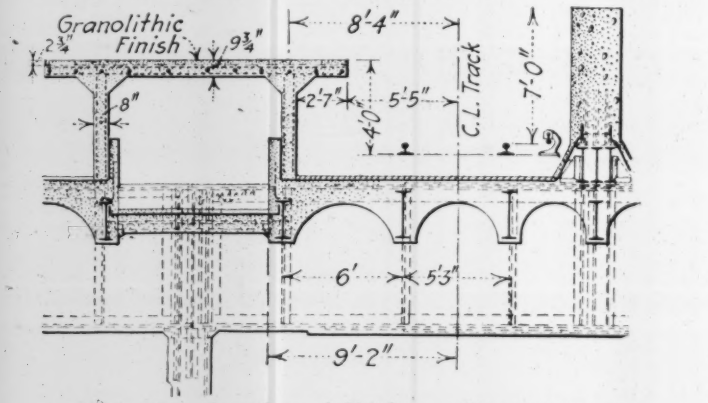


FIG. 13. TERMINAL-TRACK DETAILS

(Platforms and platform tracks. The rail blocks are of white oak in the loop tracks, yellow pine elsewhere.)

block is vacant for the present, and the building columns are not yet placed; they will be set through holes cut in the floor concrete when the erection of a building in this block is proceeded with.

The support of the main station shows the opposite solution for practically the same conditions (i.e., track arrangement such that the building columns can continue down to the footings without offset). The designers did not think it necessary to isolate the track floor and the building frame, and therefore the girders of the track floor are framed directly into the building columns. The framing is illustrated by a vertical section in Fig. 12.

Difficulties introduced by the track arrangement required the columns of street viaducts and buildings to be supported on girders of the express floor, at many points. A typical piece of the framing is shown by diagrammatic plan in Fig. 12, from the block between 46th and 47th Sts. east of Park Ave., in the main ladder-tracks of the express level. Here are seen independent columns for building and track floor, columns carrying both track girders and building loads, and building columns supported on track-floor girders. A vertical section showing a track girder and the support upon it of the building column is also shown.

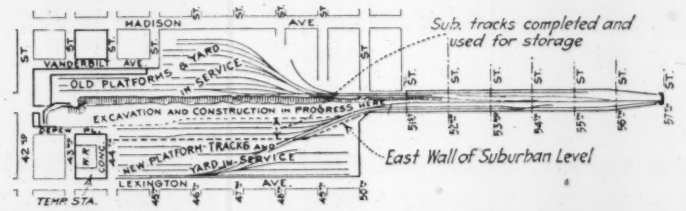

MADISON AVE.
VANDERBILT AVE.
Sub. tracks completed and used for storage
OLD PLATFORMS IN SERVICE
EXCAVATION AND CONSTRUCTION IN PROGRESS HERE
NEW PLATFORM TRACKS AND YARD IN SERVICE
East Wall of Suburban Level
LEXINGTON AVE.
TEMP. STA.

FIG. 14. PLAN OF TERMINAL DURING CONSTRUCTION WORK, JULY 1, 1909

As illustrated by the sketches above referred to, the general type of track-floor framing in the terminal comprises transverse (east-west) main girders extending between columns, and longitudinal secondary girders or

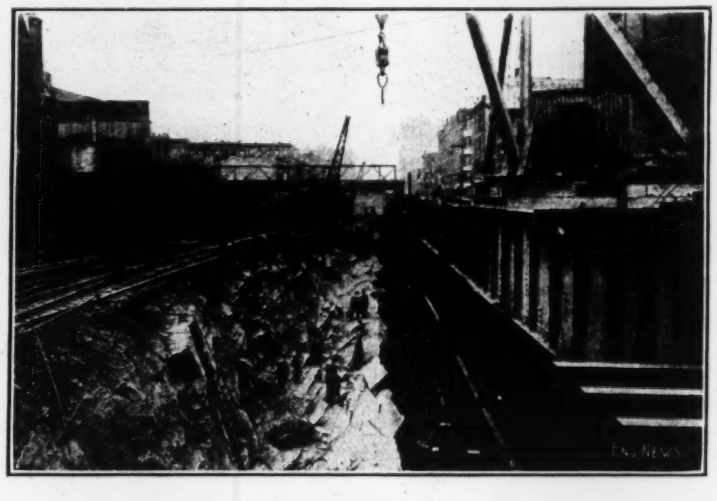


FIG. 15. CONSTRUCTION WORK NEAR NORTH END OF GRAND CENTRAL TERMINAL YARD

(View north from 50th St., Dec. 5, 1908, showing at left old tracks, at right new suburban, express and street levels. Street level at middle of picture.)

stringers, between which latter are formed the concrete arches of the floor. The stringers are framed into the webs of the girders, to minimize the floor depth. The girders are single or duplex plate-girders (in some cases two box-girders), 8 to 10 ft. deep, spaced usually about 20 ft. apart. The stringers are I-beams or built I-sections, 30 to 36 in. deep, spaced 4 to 6 ft. apart. The duplex-girder arrangement is used where columns rest on the girders, and a grillage of I-beams placed across the top flanges of the girders (the girders of the pair being 4 to 5 ft. apart) supports the column base.

A different arrangement is used in part of the northerly end of the yard. The main girders are longitudinal, and transverse beams rest on their top flanges. The longitudinal girders naturally are below the ceiling, but are between the tracks, where they do not infringe on the railway clearance. As the girders must follow the tracks,

the beam connections are often skewed, whereas few skew connections occur in the other arrangement.

The terminal area slopes up both to the west and to the north, but the steelwork is set level, in stepped arrangement. The floor slope is worked out in the concrete.

The chief peculiarity of the main-station framing is that the columns supporting the roof (and suspended ceiling) around the main concourse are made strong enough to carry a future 20-story superstructure surrounding the concourse. On account of the width of the concourse, very heavy loads would come on the columns (outside only) under this condition. These columns are constructed as braced towers of four columns each. At present only the light roof-trusses of the concourse roof rest on these columns.

The steel framing throughout the terminal was designed for railway loadings on track floors, highway-bridge loadings fixed by the city on the street viaducts, and city building-code loadings on the columns of buildings. Roughly stated, the load above the track floor (where buildings occur) amounts to about 1800 lb. per sq.ft. except at walls, and here it amounts to about 45,000 lb. per lin.ft. of wall.

The express-track floor has an average thickness of 8 to 10 ft. south of 48th St., and about 2 ft. north of 48th St., varying considerable with local design, however. The dead-load averages about 450 lb. per sq.ft. of express-track floor, and from 200 to 415 lb. per sq.ft. on the street viaducts. The live-load of the express floor varies considerably (i.e., as equivalent uniform load); its highest value is about 950 lb. per sq.ft. north of 50th St. and about 525 lb. per sq.ft. south of 50th St. These figures are for track area not interrupted by platforms; averaged over tracks and platforms the live-load is about 400 lb. per sq.ft.

The steel columns of the suburban story average 50 to 60 sq.in. each, and are generally of box section with reinforced corners. They support floor areas of 250 to 950 sq.ft. (spacing 14½ to 50 ft. east-west, 13½ to 27½ ft. north-south). The maximum column load from track-floor and street loadings (i.e., excluding building loads) is about 800,000 lb. live-load, plus dead-load. The absolute maximum of column loading (live and dead, building loads included) is 3,700,000 lb.

The columns of the express story are much wider spaced where they carry viaducts. The floor area per column ranges from 600 to 1320 sq.ft., and in one case in Park Ave. even up to 1720 ft. The maximum live-load is 650,000 lb. These viaduct columns are generally made up of four Z-bars with web, except that under Park Ave. all forms of section are used: Z-bar, channel, box, and built I with corners reinforced by angles.

The heaviest column load supported by a girder is 1,920,000 lb. The greatest bending moment in the paired girders supporting columns is about 8,000,000 ft.-lb. These girders weigh up to 1750 lb. per lin.ft., or for a girder length of 40 ft. about 35 tons.

The horizontal steelwork is divided by expansion joints, longitudinal and transverse, spaced about 200 ft. apart. The construction where tracks cross the joint is illustrated by a detail in Fig. 12. Where possible a "high-type" joint was used, for example at longitudinal joints at collision walls between tracks; this required no steel construction (except expansion seats for the girders on one side of the joint), and the waterproofing was simply carried up along the wall about 30 in. and turned into a horizontal separation in the concrete, the upper part of the wall being separately footed on the opposite side of the framing.

The column foundations are rock, practically everywhere; a few points were found where soft ground dipped down below the yard floor level and here caissons were sunk or concrete piles driven. The fact that the entire yard excavation was in rock (the tough mica-schist of Manhattan Island) eliminated all difficulties in the way of foundation.

The columns between tracks are housed in concrete piers for protection. Where regular running tracks adjoin, these piers extend to a height of 7 ft. above rail, while at storage tracks they are only 4½ ft. high. The upper parts of the columns are protected generally with

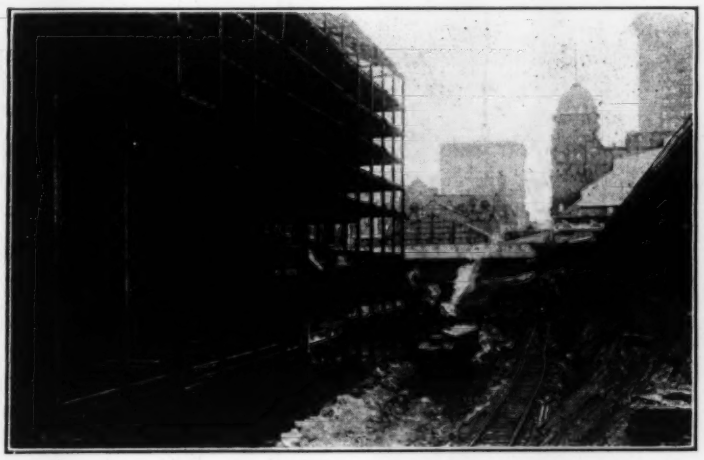


FIG. 16. LOOKING SOUTH ON LINE OF PARK AVE., DEC. 5, 1908

FIG. 17. LOOKING NORTH ON LINE OF PARK AVE., JAN. 19, 1909

FIGS. 16 AND 17. EXCAVATION ON WEST PORTION OF OFFICE-BUILDING SITE

(Old platform tracks in service on upper level, construction track on bench, pits for column-footing grillages on lower level in Fig. 17, frame of east portion of office building erected. In Fig. 16 the dome in the background marks the east tower of the old station; to the right is the Belmont Hotel, S. W. corner 42d St. and Park Ave. In the same view the end of the new steelwork is between 43d and 44th Sts., and south of it is the area now covered by the station part of the new building. In Fig. 17 the Howe truss at 45th St., carrying foot traffic across the excavation, forms the connection between the completed east portion of the new 45th St. viaduct (back of the building steel) and the remaining part of the old 45th St. footbridge. The integral character of express floor support and building support is evident from the views.)

concrete on wire mesh. All steelwork throughout is fireproofed with concrete.

Construction; Temporary Station

The construction of the new work in the place of the old without disturbing or interrupting the dense terminal traffic of the two railroads depended upon first clearing the eastern part of the site and building the new trackage and a temporary station here, and then gradually working westward with the reconstruction across the old station, crowding the traffic of the old tracks toward the west and expanding the new trackage westward from the first tracks laid into the temporary station.

It was possible to do this most conveniently by utilizing the ground story of the existing Grand Central Palace building lying between Lexington Ave. and Depew Place, 43rd to 44th Sts., as a passenger station in conjunction with the new building erected in the block just north of this and the yard tracks at the express level which were constructed here under the general plan.

Construction work was begun in the entrance stem of the yard, between 50th St. and the tunnel portal, the latter being at the same time moved north from 56th to 57th St. The old four-track entrance occupied only the middle part of Park Ave., while the new entrance was to extend from building line to building line. Before excavating down to the new (lower) track level, the approach was widened on the west side on the old level (autumn, 1903), and two tracks added. Then widening was started on the east side of the street (1904), carried down to new suburban level, three tracks laid at new grade, and a corresponding width of the framework for express floor and street was built, including the double-track incline connecting the express with the suburban level. Thus an entrance was obtained to the east side of the yard for handling work trains and for connecting with the finished tracks at new level as soon as laid. Excavation along the Lexington Ave. edge of the yard was begun the same year (1904) between 50th and 45th Sts.

Fig. 18. Looking North from 45th St. Bridge, Oct. 1, 1909

(Old yard at left, excavation in progress along rock face, work tracks on suburban level, completed portion of express level with ballasted tracks and temporary platforms, and at right a part of 46th St. viaduct.)

By 1906 the work on the excavation, steel erection and tracklaying had progressed far enough westward that the temporary station could be established and suburban traffic diverted to it. Shortly after, some of the through trains also were handled in and out of the temporary station.

The shifting of traffic from the old station to the temporary station went on progressively, as excavation advanced westward across the terminal, reducing the number of tracks in the old yard and adding to the available tracks on the new levels. On June 4, 1910, the old station was finally abandoned; only two platform tracks of the old yard then remained, and 20 platform tracks on the upper (express) level of the new terminal were in use. Work immediately began at demolishing the old station and excavating the site, followed by erection of steel for the new station. By Oct. 27, 1912, the new building was completed so far that its suburban floor could be put in service, and on Feb. 2, 1913, practically all remaining facilities (express concourse, waiting-room, etc., but not the Incoming Station) were opened to public use.

The plan Fig. 14 shows in outline the conditions existing some time before the old station was closed. The drawing brings out clearly the general course of procedure. The views Figs. 15 to 18 show different parts of the terminal yard during construction.

The size of the work may be represented by these figures: Total excavation, 3,000,000 cu.yd., of which rock 2,000,000 cu.yd.; steel framework, 95,500 tons, of which 29,000 tons in the main station, and 51,000 tons in the express floor (suburban roof) of the terminals. Some 38,000 tons of steel in addition are required for the framework of other buildings on the terminal area already built or being built.

The terminal construction was begun as a contract undertaking, the O'Rourke Engineering Construction Co. being the contractor. The uncertain conditions of the work led to a change in the system, however, after several years of construction, and the larger part of the

work was done by the railway direct. Building erection was done wholly by contract.

Miscellaneous

Signaling—The interlocking plant of the terminal comprises a number of towers, indicated in Fig. 5. The two main towers total 762 levers, of which the suburban-level tower has 400 levers and the express-level tower 362. The system is all-electric, using motor-operated switches and signals.

Drainage—A sewer was built under the terminal at 46th St., continuing on to the East River. This sewer is independent of the city system. It takes all surface drainage and sanitary sewage from all parts of the terminal area except parts of the main station, which are drained to city sewers. The drainage of the pipe and trucking subways (below sewer level) is handled by automatic motor-driven pumps.

Lighting and Power—The service plant at 50th St. (see site plan Fig. 3) furnishes direct current for lighting and power over the whole area. The lighting supply is at 120 volts, the power supply at 240 volts. They are fed from the incoming 11,000-volt transmission-line current in summer, and the Service Plant serves as standby. In winter, however, when much steam is required for heating, the Service Plant is in full operation and generates current for lighting and service power. Traction current is produced from the high-tension line current throughout the year.

The station lighting is done by incandescent lamps almost exclusively. The train rooms are lighted by large-unit tungsten lamps suspended directly under the ceiling, one per panel, at about 20-ft. spacing.

The piping system of the terminal yard, carried to all tracks, includes cold water, hot water, compressed air, steam, and vacuum (for cleaning cars). The train rooms and the main station and office-building are ventilated by air supply and exhaust systems handled at various local centers by motor-operated fans. Some of the heating is done through the ventilation supply, indirect radiation being inserted in the ducts.

Fire-Protection—A fire-protection piping system extends all through the terminal. It has about 300 hose connections. There is a station fire department, called by an alarm system having 125 call boxes, with connection also to the city fire department.

Cost—No information as to the cost of the terminal is given by officials of the railway.

Design and Construction

The design of the terminal was begun under W. J. Wilgus, Vice-President and Chief Engineer of the New York Central & Hudson River R.R., and developed under his personal direction until he resigned, in 1907. The constructional engineering was in charge of A. B. Corthell, Terminal Engineer, until 1906. Since then it has been under the jurisdiction of G. A. Harwood, Chief Engineer of Electric Zone Improvements, by W. L. Morse as Terminal Engineer, with W. J. Thornton, Designing Engineer, and E. D. Sabine, Resident Engineer. The electric equipment was worked out under E. B. Katte, Chief Engineer of Electric Traction. Architectural problems were handled by Reed & Stem and Warren & Wetmore, in association, under C. A. Reed, until the latter's death in 1911, since which time Warren & Wetmore have carried on the architectural work. Signal installation was directed by W. H. Elliott and Azel Ames, Jr., and since 1909 by H. S. Balliet. W. F. Jordan has been manager of construction work in the terminal since the railway took over the execution in preference to continuing under contract.

The design of the terminal has been subject to joint approval of a vice-president of the New York Central and a vice-president of the New York, New Haven & Hartford Ry. Both railways, also, operate the terminal (through a manager appointed jointly), and share the expense of operation, maintenance, and fixed charges. The terminal is, however, constructed exclusively by the New York Central & Hudson River R.R. Co.

A New Street Traffic Regulation at Los Angeles, Cal.

By Charles K. Mohler*

The congestion of vehicle traffic in the business districts of large cities has been increased enormously by the use of automobiles and motor-driven trucks. In Los Angeles, Calif., the number of motor-driven vehicles is probably larger in proportion to population than in any other city. In addition to the danger and confusion, the roadway space actually occupied by vehicles has produced very serious problems.

The indiscriminate occupancy of the roadway by vehicles standing at the curb is not only very wasteful of roadway space, but becomes a source of delay and danger to other traffic. This is particularly true of vehicles standing at the curb at points where street cars have to stop. As Chief Engineer of the Railway Department of the Board of Public Utilities of Los Angeles, the writer recommended to the Board that an ordinance be passed to prohibit vehicles standing at such points. The question was taken up with the head of the traffic bureau of the Police Department, and such an ordinance was prepared (under the supervision of Lieut. J. L. Butler).

Under the old conditions, vehicles were allowed to stand not less than 40 ft. from the intersection. Under the new ordinance the distance is from 80 to 150 ft., and the Board of Public Works is directed to place signs at the points designated by the Board of Police Commissioners. Between the sign and the street intersection vehicles may stop only long enough to receive or discharge passengers and goods.

There is still another good reason for keeping standing vehicles well back from the approach to a crossing, which is that here is always the point of congestion for moving vehicles on account of the inevitable crossing delays. To provide additional roadway space for moving vehicles and remove the obstruction of standing vehicles at these points, would be reason enough of itself for the new regulation. The ordinance went into effect the latter part of April, 1913.

Freedom of Panama Canal Laborers from Sunstroke—The third case of sunstroke or thermic fever on the Isthmus, reported by the Canal physicians during the 8½ years of American work, occurred on Dec. 5, at Miraflores locks. An Italian laborer, who had been on the Isthmus only 10 days, was stricken at 4 o'clock in the afternoon after he had completed 10 hours of work.—["Canal Record."]

*Chief Engineer of the Railway Department, Board of Public Utilities, Los Angeles, Calif.

Double-Gage Track on an Electric Railway

Although a majority of city and interurban electric railways are built to the standard gage of 4 ft. 8½ in., there are numerous lines of narrower and wider gage, and in case where lines of different gage meet, or when they enter the same city, there are special difficulties and problems to be encountered. This condition exists at Wheeling, W. Va., and for the accompanying information as to the track construction we are indebted to W. A. Underwood, Superintendent of Maintenance-of-Way of the Wheeling Traction Co. The traction company operates lines of 5 ft. 2½ in. gage and 4 ft. 8½ in. gage, and has approximately 9½ miles of mixed or double-gage track. The wider gage is used on all the lines of the system entering Wheeling, except the Pan Handle Division, which is a standard-gage interurban line 17 miles long, operating between Wellsburg and Wheeling. To allow

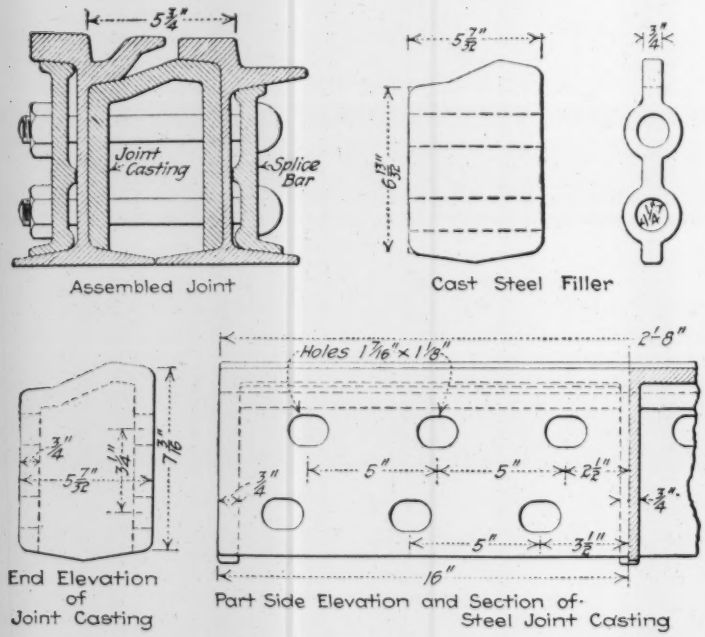


FIG. 1. TWIN RAIL CONSTRUCTION WITH 9-IN. GIRDER RAILS FOR DOUBLE-GAGE TRACK (4 FT. 8½ IN. AND 5 FT. 2½-IN. GAGE); WHEELING TRACTION CO., WHEELING, W. VA.

cars of this division to enter the heart of the city, it became necessary either to bring all tracks to a uniform gage or to use the double-gage construction. The latter plan was adopted.

The straight track work is of two types. The first type has 9-in. girder rails, the two rails on one side of the track being bolted together by 1-in. bolts at intervals of 6 ft. and adjusted to position by cast-steel fillers on these bolts, so as to maintain the 6-in. distance between gage lines. The bases of the two rails being in contact, the rails are spiked on the outside only, like a duplex rail. The joints are spliced by two outside splice bars and an inside filler of cast steel; this filler is 32 in. long, with oval holes 1 7/16 × 1⅛ in. cored for the bolts. The casting is of channel or trough section, fitted to the heads and bases of the rails; it is of ¾-in. metal, and is closed at the middle and ends by diaphragms of the same thickness. This track construction, with the spacing blocks and joint fillers, is shown in Fig. 1.

The other type of track has 70-lb. T-rails of the Am. Soc. C. E. section, and here each rail is spiked on both sides, their bases being far enough apart to admit the spikes. The joints are spliced with the Continuous splice bars as made for use with frogs, having the base plate extending under the full width of the rail. Between the rails is a filler shaped to form the flangeway for the outer rail; this filler is 30 in. long, and is stiffened by diaphragms at the middle, the ends and two intermediate points. This construction of track and joints is shown in Fig. 2.

With the close spacing of the twin rail or double rail,

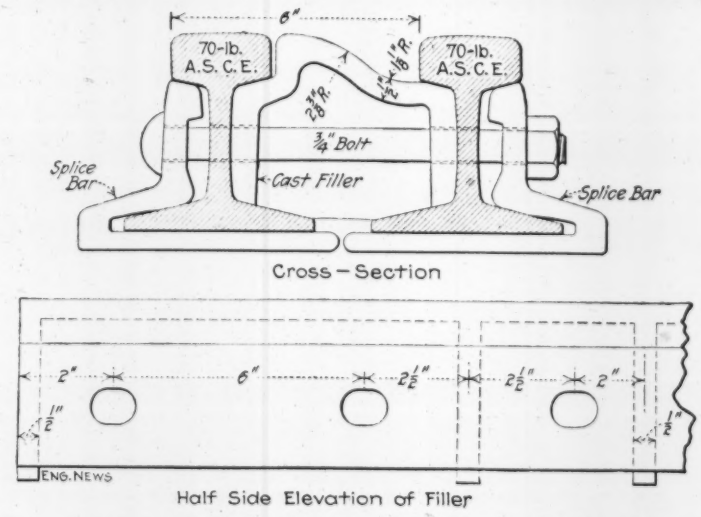


FIG. 2. TWIN RAIL CONSTRUCTION WITH 70-LB. RAILS FOR DOUBLE-GAGE TRACK; WHEELING TRACTION CO.

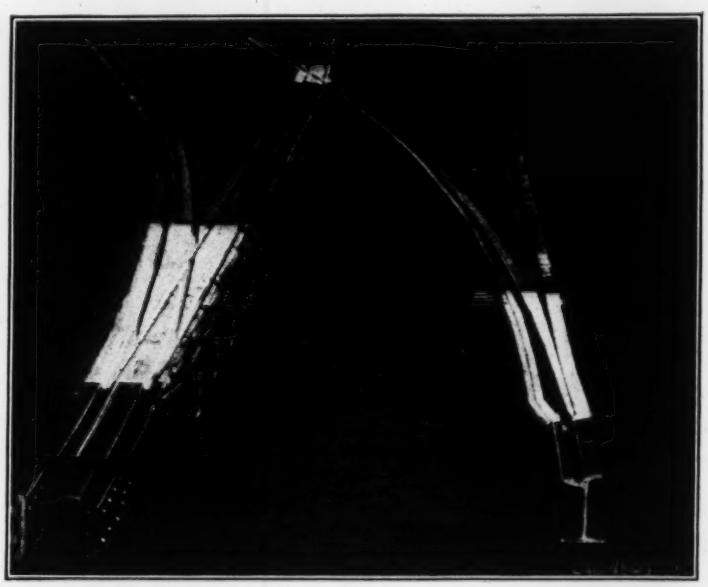


FIG. 3. TURNOUT ON DOUBLE-GAGE TRACK, WITH TONGUE SWITCH-RAIL AND DOUBLE-POINT FIXED MATE; WHEELING TRACTION CO.

and the use of the inside filler blocks at rail joints, it was not practicable to use an ordinary bond compressor to apply the electric bonds at the rail joints. For this reason the company adopted the pin-driven type of bond, outside of the splice plates. At all points where the 9-in. girder rails connected with the 70-lb. T-rails, the compromise joints were made by welding together short pieces of each section, to form a connecting rail, and then splicing these between the two types of track rails.

A specially interesting feature of this double-gage track is that it required several pieces of special work,

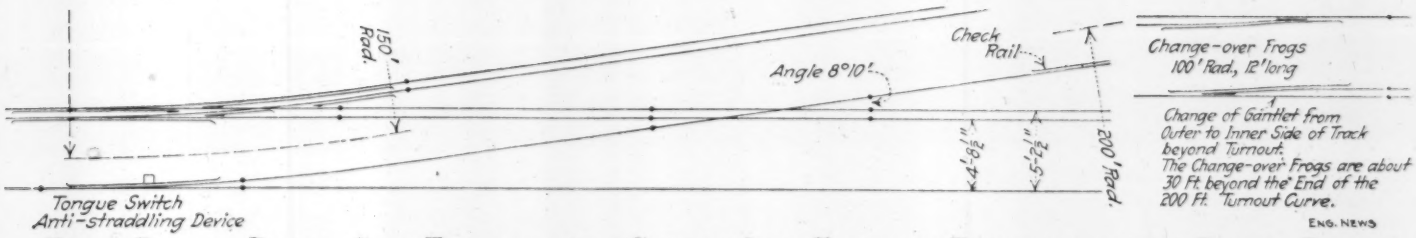


FIG. 4. PLAN OF DOUBLE-GAGE TURNOUT, WITH CHANGE-OVER FROGS FOR TRANSFERRING THE DOUBLE RAIL FROM INSIDE OF SECOND TRACK TO OUTSIDE OF TURNOUT; WHEELING TRACTION CO.

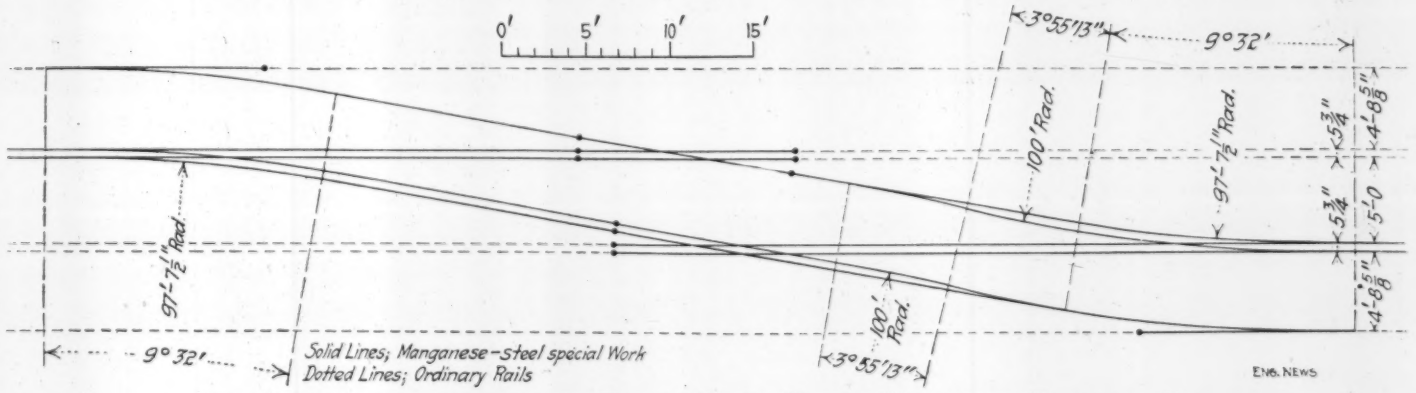


FIG. 5. PLAN OF CROSSOVER ON DOUBLE-GAGE TRACK; WHEELING TRACTION CO.

consisting of crossings, curves, turnouts, change-over mates and crossover. These are of hard-center construction, made with manganese steel, and some of the switch parts are said to be the heaviest pieces of this kind ever made. This work was built by the Pennsylvania Steel Co. The mate is the fixed switch point used in connection with the single-tongue switch employed in street-railway work, and the change-over mates are used to change the double rail from one side of the track to the other. Fig. 3 shows a turnout assembled, with the tongue switch at the right, the double mate at the left, and the three-way frog at the intersection of the single and double rails. Fig. 4 shows the turnout at Glenova at the end of double track on the double-gage line. The turnout necessarily puts the double rail on the outer side of the second track, but on the double-track part of the line this rail is on the inner side of each track. A pair of change-over frogs is therefore put about a rail length from the end of the turnout curve, where the two tracks are parallel. This, as will be seen from the diagram at the right of Fig. 4, transfers the double rail from the inner side to the outer side to conform to the turnout-rail arrangement of the turnout. This turnout and track are laid with 70-lb. rails.*

FIG. 6. END OF CROSSOVER FOR DOUBLE-GAGE TRACK; WHEELING TRACTION CO.

The crossover, Fig. 5, has the change-over mates embodied in it. This saves having a pair on each end of the crossover on one track, which would be required in any other arrangement of a double-gage crossover. This scheme Mr. Underwood believes to be original with the Wheeling Traction Co. Fig. 6 shows one end of this crossover.

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Oxyhydrogen-flame Working Under Water is said to be accomplished successfully by means of a special form of burner recently invented. This burner consists of an ordinary oxyhydrogen burner with the addition of a bell or hood shielding the gas orifice from the water, and a compressed-air supply. A. Heckt, of Kiel, Germany (12 Lübecker Chaussee) is marketing the apparatus, and also carries out subaqueous metal-cutting work. Information from him tells of successful demonstrations where a bar of iron 2½ in. square was cut through in 30 sec. at a depth of 16 ft. under water, a 12-in. slot was cut in ⅝-in. plate in 1½ min., etc.

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Flood Tests of Concrete Bridges, Philippine Islands—Severe tests were given the three reinforced-concrete bridges recently completed in Occidental Negros, P. I. On the Imbang bridge, a 2-span (25 m. each) reinforced-concrete arch bridge, the flood waters completely filled the arches and several hundred logs became jammed above the bridge, causing the water to overflow the surrounding country. One log some 3 ft. in diameter was lodged in one of the small spandrel arches and was not removed until the flood had subsided. The jam remained in place three days before it could be removed. No damage was done to the bridge except that the water scoured out the foundation around the north abutment to the top of the foundation piles, and cut into the clay bank on the north side of the river some 25 ft. The second bridge was the Matabang bridge, a 2-span (21 m. each) reinforced-concrete arch bridge. Here a jam of bamboo raised the water, and in order to relieve the strain on the bridge, the two approaches to the bridge were cut. The water subsided without any damage to the bridge. On the Tanalao bridge, a reinforced-concrete slab-and-girder bridge, having four spans of 12 m. each, the water rose 1 m. above the balustrades. The north approach of the bridge was washed out, but no damage done to the bridge itself. Strange to relate, this is a tidal stream and the bridge is located not over one kilometer from the ocean. It would seem scarcely possible that the water should rise to this elevation above the ocean, the elevation reached being 5.4 m. above low tide. ["Quarterly Bulletin" of the Bureau of Public Works, Philippine Islands, Jan. 1, 1913.]

*Double-gage turnouts on the Panama R.R. and for mine tracks were illustrated in our issues of Nov. 23, 1911, and Jan. 25, 1912, respectively.

The Effect of the Omaha Tornado on Structures

By Albert C. Arend*

The tornado which passed through Omaha on Mar. 23, 1913, at about 5:50 p.m., followed a direct northeasterly direction, through the residential section of the city and passed on across the Missouri River into Iowa. Its path averaged nearly 1000 ft. wide and was 5½ miles long. Its direct effects have been officially summarized as follows: Property loss, $5,000,000; deaths, 139; injured, 322; houses demolished, 642; additional houses and other buildings damaged, 1027; churches wrecked, 11; schools damaged, 8.

There are other effects, however, of a scientific interest, and, as the stresses produced were of such a definite and consistent nature, some valuable engineering conclusions are suggested which might be utilized to make structures proof against such forces.

The writer has carefully traversed the path of the tornado and examined the effects, and in addition has collected the testimony of many other eye-witnesses as to the attendant phenomena.

The cloud formation was of the typical funnel type, seemingly about 600 ft. high with the point touching the earth. From some points of vantage this point was a lurid fiery mass, while from others it was described as like a large roll of dark paper rolling along rapidly, with ragged edges or ends flashing out spasmodically. Its passage was preceded for several minutes by a roar like that of many railway trains. It probably traveled at the rate of 30 to 40 miles per hour. It was followed or attended by a mass of flying débris which traveled always endwise and at an angle of about 10° to the ground for such articles as studs, plank and brick. Such débris had sufficient momentum to penetrate sod-covered ground from 15 in. to 24 in., and when these plank struck shingle roofs laid on ⅞-in. boards, or frame-house sides, they often went right through. Such light débris as shingles, lath, mounted photographs and wearing apparel was carried from Omaha to the vicinity of Denison, Iowa, a distance of over 60 miles!

The continuous mass of flying débris was particularly well defined and was about 200 ft. wide, where it crossed a sodded field 500 to 600 ft. away from the nearest building. Many heavy articles, such as automobiles, trunks, pianos, washing machines, iron beds and people, were picked up and deposited at distances of 50 to 300 ft. from their starting point. All kinds of household contents in buildings were often "blown" or sucked out through the roof and window openings, and in turn similar articles and débris in general were brought in and deposited in their place by the inrushing wind. It should also be noted that the sensations of those actually in the path of the storm were that it was bearing down upon them like a wall of black smoke attended by a rumbling clatter likened to acres of sheet iron being dragged over cobble stones. Generally speaking, everybody was sufficiently warned to get to their basements just before the storm reached them. This accounts for the miraculously small loss of life, for there were over 6000 people in the houses which were damaged.

The tornado had been preceded by a rapidly rising temperature and a falling barometer, which had fallen two inches during the preceding 24 hours and recorded as low as 27.93 in.* at the weather bureau, which was 1½ miles from the storm. It had been raining, with the wind from the northwest for probably an hour before, but the rain had ceased and the wind changed in direction to the southwest, when the tornado approached. It was immediately followed by a general moderate rain, accompanied by a splattering of mud in the path of the tornado.

The storm did not follow any well defined lines of streams or valleys. It entered the city by way of the Saddle Creek valley, and followed the Missouri Pacific Ry. tracks to Leavenworth St., when it swung off to the east for a block and then traveled in a comparatively straight line, going up hill to the Medical College Laboratory building and then down a 10% grade for about 300 ft. to 42d and Harney Sts., where the damage was intense, then advancing up the side of a 10% slope to 40th and Farnam Sts., and thence across a depression and up the side of a 5% slope, etc. In this manner it continued on across the city, without ever leaving the ground once, to 14th Ave., then down a 50-ft. embankment to the Missouri Pacific roundhouse and railroad tracks, and cutting its way through the Illinois Central Ry. trestle, it proceeded on across the Missouri River. It seemed to be particularly partial to groves of trees, etc., and often widened its path to take them in and down.

The great similarity in most features to the St. Louis tornado (Engineering News, June 4, 1896, and June 11, 1896, pp. 374 and 388) seems remarkable, and the intensity of the stresses was evidently almost identical. In this connection it should be noted that there were probably no examples of reinforced-concrete construction in the St. Louis storm in 1896, and that if there had been, the sentiments expressed in the editorial (Engineering News, June 11, 1896, p. 384) on that occasion would have been somewhat modified. It is now at least practicable for engineers and architects to provide against the destruction of buildings and the attendant loss of life; and it remains only for their clients to decide whether they will "stand for" such special features of design and moderate additional costs as may be essential.

The well defined and consistent stresses which were observed are as follows: There was a whirling or twisting motion which turned every house, that was moved upon its foundation at all, in a direction opposite to the travel of the hands of a clock; there were but few exceptions noted to this rule, and they were probably caused by the way the onrushing wind and débris happened to strike the house as this force released it.

As the storm approached, the sudden relief of atmospheric pressure on the outside caused anything containing air to explode unless it could resist the stresses or be otherwise relieved, and as the pressure was less above than at the surface, it tended to lift or float things; windows blew out, roofs blew off entirely or lifted up to equalize the air pressure and dropped back again; sides of buildings blew off, doors and partitions buckled or fell and many frame houses were picked up bodily and carried distances from a few inches to a hundred feet. As the tornado cloud passed on and the onrushing wind restored the air-pressure equilibrium, these were dropped

*Consulting Engineer, Brandeis Building, Omaha.

*29.85 in. is normal.

from the particular height at which they happened to be, resulting in the necessity for a house-mover in some cases and a mass of wreckage in most cases.

Second-floor windows blew out more often than first-floor windows. Porch roofs lifted just enough to permit the columns to be carried away, and then dropped. Where roofs were well secured to cap plates and brace tied to ceiling joists, or where the space under the roof was cut up into rooms with partitions tied into the roof joists, the roof structure was not lost; but the paper, tile,

FIG. 1. RUINS OF THE PLYMOUTH CONGREGATIONAL CHURCH AT 20TH AND SPENCER STS., NEAR EDGE OF STORM BELT
(Heavy damage due to large auditorium)

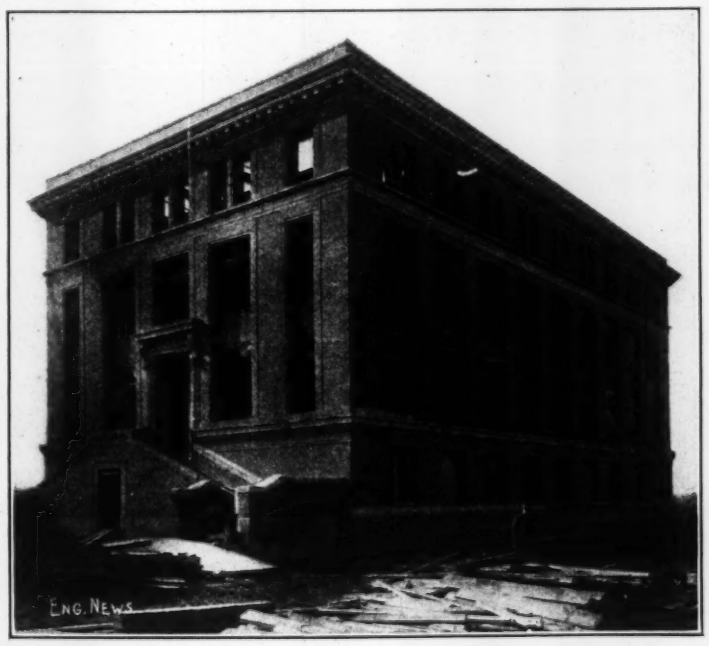

FIG. 3. MEDICAL COLLEGE BUILDING OF NEBRASKA STATE UNIVERSITY
(See "Engineering News," Apr. 10, 1913, p. 740)

slate, or shingle covering was partly blown off to relieve the air pressure and then shattered by the rain of débris which followed in the wake of the storm.

Some frame houses withstood the full force of the storm with the loss of only windows, roof, weatherproofing and chimney. Bedford coping stones 4x14 in.x4 ft. long were picked up from a wall which was laid in cement mortar and remained intact. Coping walls generally proved a particular hazard. All large undivided areas, such as church auditoriums and the second floor of a garage building without partitions, caused more complete wrecks than the surrounding buildings suffered.

Brick and stone walls laid up in lime mortar usually failed. Where facing brick had not been bonded into the backing walls with header courses and where air

FIG. 2. VIEW ON LAKE ST., BETWEEN 23D AND 24TH STS.
(This was at the center of the storm, but these well built frame houses were not moved from their foundations.)

FIG. 4. A LIGHT FRAME HOUSE PICKED UP, EXPLODED AND DROPPED

FIG. 5. WRECK OF ILLINOIS CENTRAL R.R. TRESTLE

STRUCTURAL DAMAGE IN OMAHA TORNADO

spaces existed, they exploded off. Concrete basement walls remained intact and did not injure the refugees in the basements when the house blew off; but there were many instances where brick walls did drag or tear off and cause injuries. Cement stucco on metal lath showed very little damage.

A four-story and basement medical college laboratory building, which was L-shaped in plan, with a frontage

of about 102 ft. on both the north and the east and was located on the center line of the storm, was uninjured excepting as to the 4-in. thick gypsum-block partitions; this building had concrete foundation walls, brick bearing walls laid up in cement mortar, and reinforced-concrete slab floors and saw-toothed roof supported on concrete-incased steel beams and columns, the beam centers averaging 10 ft., the floor slabs being 5 in. thick and the roof slabs 4 in. thick. The window openings, amounting to nearly 50% of the wall space, were regularly spaced and covered with muslin, as the sash were not in and the building had not yet been trimmed.

In striking contrast with this building was a two-story and basement new garage building about 66x120 ft., with brick-bearing walls, laid up in weak lime mortar, steel beams and wood floor and roof joist. The windows were irregular and limited in area and the roof blew off and walls blew down to about the second-floor line. This building was probably a 50% loss.

The Illinois Central R.R. trestle was badly damaged by the storm, 250 ft. of it being blown down to the westward of the plate-girder span over the C. & N. W. tracks, and 500 ft. of it to the eastward of same span. The easterly portion was supported on piles which projected out of the lake 10 or 12 ft.; this trestle was 28 ft. high from sill to cap, and of standard construction with 12x12-in. posts, two tiers of sway bracing per bent and two tiers of girts, besides the track stringers, each of which consisted of three 8x16-in. timbers. The bents were on 14-ft. centers with a base width of about 18 ft. for the outside posts, and the posts each had a ¾-in. drift bolt into the sill. The trestle was thrown over to the northeast almost bodily, with the rails and ties intact and at a distance of about 75 ft. from their original location. The pile bents located in the Lake were so twisted and broken that they may be properly termed demolished.

Conclusions

A reinforced-concrete building will withstand the stress of an ordinary tornado without structural damage. Well-built frame houses may withstand an ordinary tornado.

Windows are desirable relief valves, and should be regularly arranged and of liberal total area.

Large and unbroken areas should be avoided as far as practicable.

Brick walls should be laid up only in cement mortar, and face brick should be bonded into and laid solid with backing wall.

Gypsum blocks and hollow tile are undesirable for partitions and walls.

Sills should be well anchored to foundations and roofs to stud plates, and diagonal and knee braces are essential.

Roof weatherproof coverings should be actually fastened on and should not be of a brittle nature.

Partitions should be utilized to act as ties and braces.

All studs and joists should be amply strong and should be secured at ends against internal and external stresses.

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Turpentine, satisfactory for general use, can be made from western yellow pine as well as from long-leaf southern pine, which furnishes the bulk of the present supply, according to reports of the U. S. Department of Agriculture. The Forest Service has been studying the oils of the western yellow, piñon, digger, sugar and lodge-pole pines as sources of rosin and turpentine. A product very similar to turpentine can be obtained from the western piñon, which is a short scrub pine scattered throughout the Southwest.

A New Design of Electric Locomotive for the New York Terminal Zone of the New York Central Railroad*

The changes gradually introduced in the construction of the 600-volt direct-current locomotives, used by the New York Central & Hudson River R.R., in its Grand Central Terminal electric zone, have resulted in a design showing important new mechanical features. The company has in service 35 locomotives built in 1906 (see Engineering News, Nov. 17, 1904, for a detailed description of the type), 12 built in 1908, and one of the new type. The oldest units have been reconstructed in accordance with the 1908 design, so that these 47 are all of the same 115-ton 4-8-4 type, carrying four gearless bipolar motors.

The one experimental unit of this latest design was given a series of tests and trial runs on the Harlem division, after which it was immediately placed in the service of the terminal zone. A contract was thereupon given the makers, the General Electric Co., for nine more and these are now under construction.

This new type is lighter than the older one, weighing

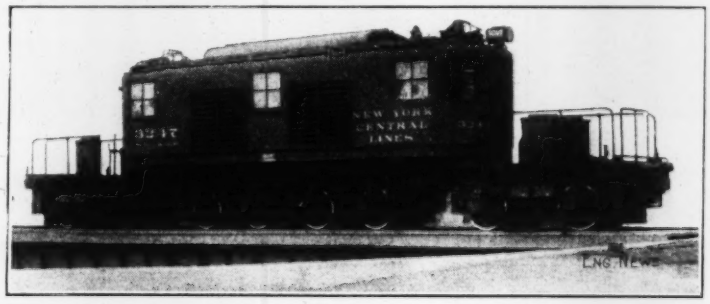


Fig. 1. The 4-4-4-4 100-Ton Electric Locomotive of the N. Y. C. & H. R. R.R. For New York Terminal Service

100 tons against 115; at the same time it is more powerful, developing 1400 hp. continuously, with a short-time maximum of 5000 hp. It is claimed to be able continuously to develop a tractive effort of 10,000 lb. at 60 mi. per hr. or sufficient to haul a 1000-ton train. The one-hour rating is 13,500 lb. at 54 mi. per hr. The motor equipment has 50% excess capacity over that of the older locomotive, and the speed capacity is raised 25%.

The original New York Central electric locomotives had guiding wheels in the form of a pony truck with 28,000 lb. load on the axle. There were four driving axles, each carrying the armature of a direct-current, bipolar, gearless motor. To improve the riding qualities, a guiding bogie truck having two axles was substituted for the pony truck. A further development in a subsequent type was to increase the distance between the guiding trucks and the rigid wheel base. The riding qualities were improved, but at a loss in the mechanical efficiency of the locomotive; for about 40 tons of surplus weight had been added and were carried by the bogie trucks for the sole purpose of guiding the locomotive. The addition of motors to the bogie trucks and the elimination of

*From information furnished by the General Electric Co., Schenectady, N. Y.

ineffective weight was the next trial step. A still greater separation of the fixed wheel base and the guiding trucks lengthened the machine so as to necessitate splitting the main frame into two articulated parts, supporting an independent cab structure. A number of minor changes necessarily accompanied the important ones noted.

In general, the locomotive may be described as a 4-4-4-4 type, having an articulated frame with bogie guiding (but driving) trucks at each end. The cab, containing the engineman's end compartments and that for the operating mechanism, is swung between the two parts of the frame on center pins. Each frame section rests on two two-axle trucks having a driving motor mounted on each axle. These cannot be distinguished as "main-driving" or "leading" trucks, since all the axles are driving axles; but they are termed for clearness "rigid trucks" and "swivel trucks," respectively.

The rigid truck is built up of heavy steel castings, the side frames being of a truss pattern with heavy top and bottom members and pedestal tie bars. The end frames and center cross frames are steel castings securely bolted to the side frames and supporting the motor fields. The whole weight of the truck is carried on coil and semi-elliptic springs resting on the journal boxes and side equalized.

The main half frame, of the locomotive, just above the trucks, is a broad box girder built of 10-in. channels with ¼-in. top and bottom plates. It is approximately 10 in. deep by 36 in. wide and 22 ft. long. The frame is bolted to the top member of the rigid truck, and extends forward over the center plate of the leading truck and backward to the heavy hinge, or knuckle, which connects the two half frames. Each half frame carries in its top plate the center pin which holds the cab in place, with the weight on broad bearing plates. All center pins are

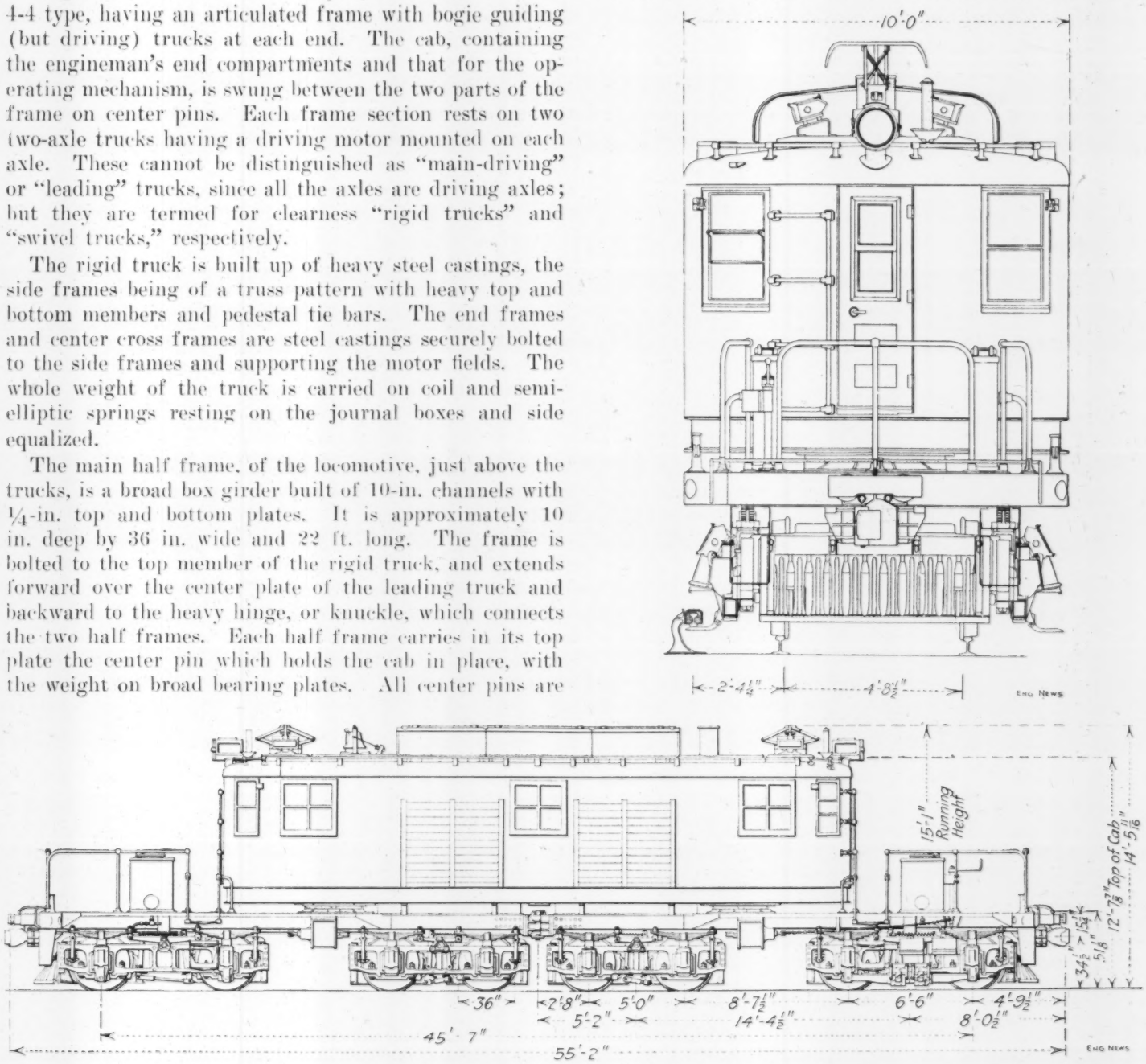


FIG. 2. SIDE AND FRONT ELEVATIONS OF NEW YORK CENTRAL 4-4-4-4 TYPE ELECTRIC LOCOMOTIVE

hollow and serve as air passages, the main box-girder frames acting as distributing reservoirs for the air delivered from the blower in the upper cab through the upper center pins and conducting it to the eight motors below. Changes in distance between cab center pins are accommodated at one bearing plate of the cab platform by room for a small longitudinal movement. The weight of the cab on the bearing plate, together with the lubrication, gives a sufficiently tight joint so that there is no leakage of the low-pressure cooling air.

The construction of the swivel or leading truck is similar to that of the rigid truck, except that it carries a center pin and is connected to the main frame through a center pin instead of being bolted rigidly to it.

This design affords a long flexible wheel base with eight driving axles, but restricts the length of any rigid portion to not more than 6 ft. 6 in.

The cab, carried on bearing plates and center pins as stated, has its weight divided between the two halves of the main frame. It is virtually a box 33 ft. long, 10 ft. wide and just under 8 ft. high, divided into three compartments. The engineman's sections, at each end, contains a seat, controller, air brake, valves, bell- and whistle-rope handles, and such parts of the control apparatus as have to be within reach of the operator. In the central section of the cab are the air compressors, blowers, contractors and rheostats, grouped so that they are conveniently accessible for inspection and repair, as well as away from the attention of the engineman who should not be distracted from his regular duties. A rather long platform is thus left at either end of the lo-

comotive; access to the cab is by doors opening out on the platforms.

A motor armature is mounted on each axle, but the magnetic circuits of two motors are combined so that there is but one magnetic system for each truck. Another way of viewing the arrangement leads to the statement that each truck carries, and is a part of, a double-armature motor. It will be remembered that the older type used in this road's service has the magnetic systems of all its four motors so combined, resulting in a rigid four-armature motor unit.

The magnetic flux path on each truck passes in series horizontally through the fields and armature of one motor, through the truck center transom and the fields and armature of the second motor to the truck end frame, and then returns to the starting point divided through the two side frames and a reinforcing magnet bar lying parallel with the side frames.

The motor is practically inclosed, and the field coils are waterproofed and armored. Each field coil is wound in a brass shell, the windings being in two decks of flat ribbon copper laid side by side. The outside turn is covered with insulation and a sheet-steel armor is clamped over it, filling the space between the sides of the shell in such a way as to protect the windings from water or mechanical injury. End shields are provided for each motor, which render it dust-tight and as nearly water-tight as is possible in any motor designed with necessary outlets for forced ventilation. As in the older locomotives, the pole faces are flattened to permit vertical play of the armatures.

Each pair of motors on a truck is permanently connected, electrically, in parallel. The pairs can be connected in running groups of series, series-parallel and parallel. They are insulated for 1200 volts, so that if, at some future time, it should be desired to operate on 1200 volts, the pairs of motors could be changed from parallel to series with the same speeds and control steps as now.

The control is by the familiar multiple-unit system with switch groups electrically operated by a small master controller. There are the usual three combinations of (1) series, (2) series-parallel, and (3) parallel, with nine, eight and seven steps in each stage, respectively. The resistances used in the various steps are mica-insulated cast-iron grids, assembled in the monitor deck of the cab.

Smooth transition between all speed points is claimed and the motors are operated close to the slipping point, which is relied upon to prevent damaging overloads. Any pair of motors may be cut out of circuit and the locomotive will then operate during the series steps with only two pairs of motors, but will have three pairs in service on the parallel-connection steps.

Current is collected by eight underrunning third-rail shoes or, when on gaps in the third rail as at crossovers, by two pantograph trolleys pneumatically operated. They can be raised for service by an engineman's foot-operated valve. As this trolley is for intermittent use, it is held raised only while the valve is held open. As protection against effects of short circuits there are main fuses (copper-ribbon magnetic-blowout type) near the third-rail shoes and pantographs, and fuses for each pair of motors.

In each engineman's compartment is an ammeter (showing current in one motor unit) and an air gage with a small gage lamp in the headlight circuit. There are two other lamps in this compartment and six in the machinery section. The lamps in one end compartment and half those in the middle compartment lamps are controlled from that end. Each engineman's space also has two electric heaters.

The motor-driven blower for cooling the motors has a capacity of 24,000 cu.ft. of free air per minute. The air compressor is a two-stage type of 100-cu.ft. per min. displacement, and pumps against a tank pressure of 135 lb. per sq.in. Between stages, the air is passed through cooling pipes under the cab platform to condense the moisture burden. The supply is stored in four 16x90-in. tanks connected in series and hung under the cab floor. Pneumatic sanders and bell ringers are used. All wiring is in steel conduit.

The leading data of this design are tabulated below:

Length inside of knuckles	55 ft. 2 in.
Length over cab	33 ft.
Height over cab	12 ft. 8 in.
Height with trolley down	14 ft. 6 in.
Height with trolley running	15 ft. 1 in.
Width overall	10 ft.
Total wheel base	45 ft. 7 in.
Rigid wheel base	5 ft. and 6 ft. 6 in.
Total weight	200,000 lb.
Weight per axle	25,000 lb.
Dead weight per axle	6,395 lb.

Sewage Treatment Plant for the Julietta Insane Hospital, Indiana*

By Charles Brossmann†

A sewage treatment plant consisting of a modified Imhoff tank, contact beds and sand filters was built for the Julietta Incurable Insane Hospital of Marion County, Ind., in 1912. The asylum has about 200 inmates at present, with an estimated sewage flow of 50 to 100 gal. per capita. The plant has been built large enough for future increase in population. The layout of the plant is shown by Fig. 1.

IMHOFF TANK — This tank (Figs. 2 and 3) which is the first one of the kind to be built in Indiana, is 8 ft. wide, 14 ft. long and 13 ft. deep. The settling chamber has an average width

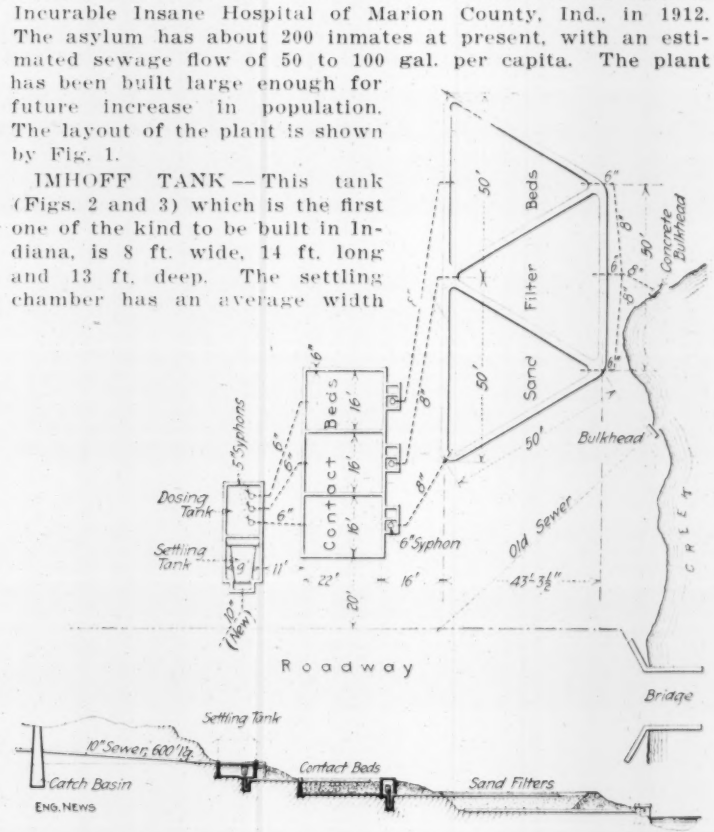


FIG. 1. LAYOUT OF SEWAGE WORKS, JULIETTA INSANE HOSPITAL, INDIANA

of 6 ft., a length of about 12 ft. and a depth of 5 ft. The rate of flow through this chamber is about 4 ft. per hour. The width of the settling chamber is greatest at its outlet end.

* Somewhat rearranged from a paper on "Sewage Disposal," read before the Indiana Sanitary and Water Supply Association, Indianapolis, Ind.

† Consulting Engineer, Merchants Bank Building, Indianapolis, Ind.

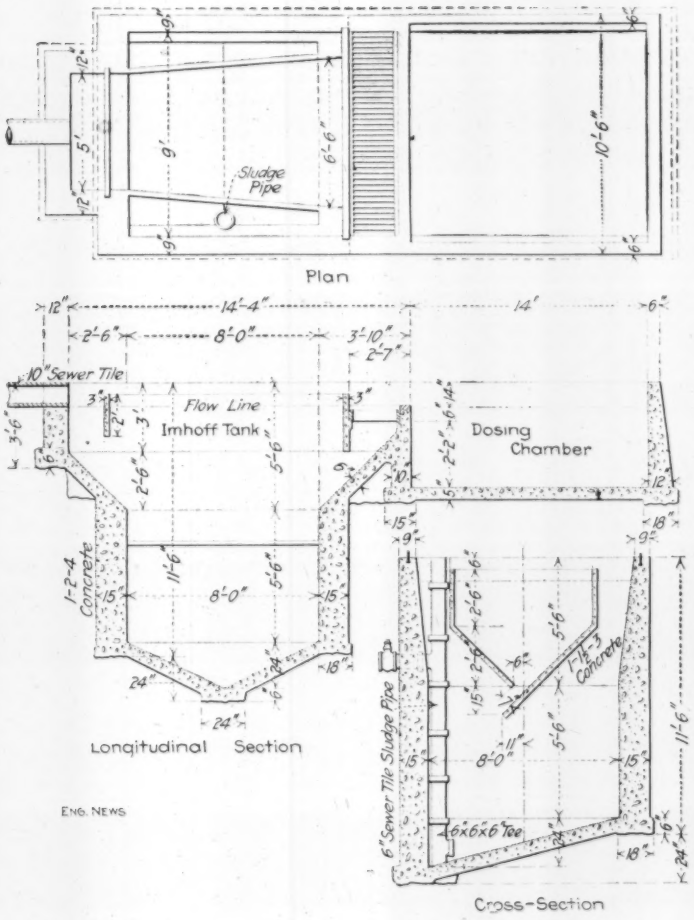


FIG. 2. PLAN AND SECTIONS OF IMHOFF TANK AND DOSING CHAMBER, JULIETTA HOSPITAL

The sewage, on coming in, passes a baffle at the front end, and at the rear end of the settling chamber a baffle is also thrown across.

The sewage flows upward and out through an adhesion screen made of ¾x10-in. plank, ¾-in. apart. The top of the screen is submerged about 2 in. below the sewage level. The purpose of this screen is to prevent anything being carried over into the dosing chamber, and thence into the contact beds, and also to serve as an adhesion rack to catch any minute floating material until it has attained sufficient weight to slide off, when it will drop to the sludge chamber below. To what extent this screen will serve its purpose cannot be said until the plant has been longer in operation, but already a considerable amount of matter adheres to it.

The portion of the sludge chamber below the settling tank has a capacity of about 350 cu.ft., which should ordinarily take care of about six months' run before blowing off, but the writer does not believe that this will serve that long owing to the large amount of foreign matter, such as vegetable wastes and paper, which seem to be discharged in considerable quantities.

The sludge chamber extends up to the open air on each side of the settling chamber and the sludge is forced up at the top, probably 10 in. higher than the water level of the settling chamber.

A blowoff pipe of 8-in. vitrified tile is placed on one side of the sludge chamber, the bottom part being a 6x6x6-in. tee, with side outlet open. The tanks slope toward this tee, which is placed in the bottom, and the sludge can be drawn off by opening the sludge valve, which is placed on the outside and about 4 ft. below the top of the tank.

A small sludge bed is to be built later on to care for the sludge.

The plant has been in operation about four months, and at the present time (Feburary, 1913) a thick heavy scum, over a foot in depth, has formed at the top of the sludge chamber. No scum or mat has yet formed on the surface of the liquid in the settling chamber.

The effluent from the tank is fairly clear and contains but little suspended matter. The odor is very slight and is not noticeable in the road, which is 50 ft. away. It is the intention to construct a roof over the tank.

DOSING CHAMBER—At the rear of the Imhoff tank there is a 2500-gal. dosing chamber (Figs. 2 and 3) provided with three 5-in. Pacific siphons.

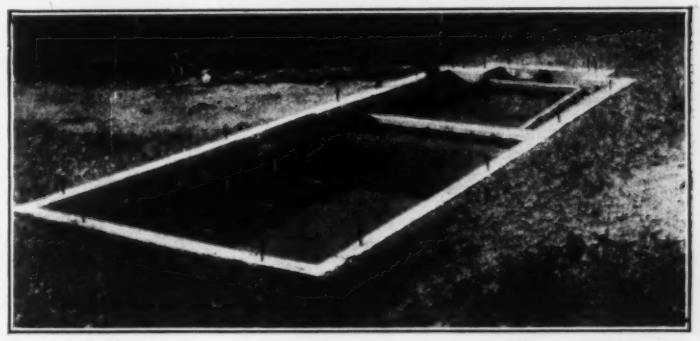


FIG. 3. VIEW OF SEPTIC TANK AND DOSING CHAMBER, JULIETTA HOSPITAL

CONTACT BEDS—The dosing apparatus discharges the tank effluent into three 16x22-ft. contact beds (Fig. 4) filled to a depth of 33 in. with ½ to 2-in. broken stone, the bed being retained by reinforced concrete.

The sewage is distributed over the beds by means of heavy plank, painted with asphaltum. The underdrains are of 4 and 6-in. vitrified tiles, laid with open joints.

The contact beds stand full for about two hours and stand empty some six hours. The effluent of each contact bed is discharged to the sand filters by means of a 6-in. Pacific timed siphon.

SAND FILTERS—There are three sand filters (Fig. 5), triangular in shape, each side being 50 ft. in length. The depth of sand is 30 in., and below this is placed gravel ranging in size from ⅛ to 1 in. The underdrains are of vitrified tile, laid with open joints, and are covered with large broken stone. The distributors are made of 1½-in plank, painted

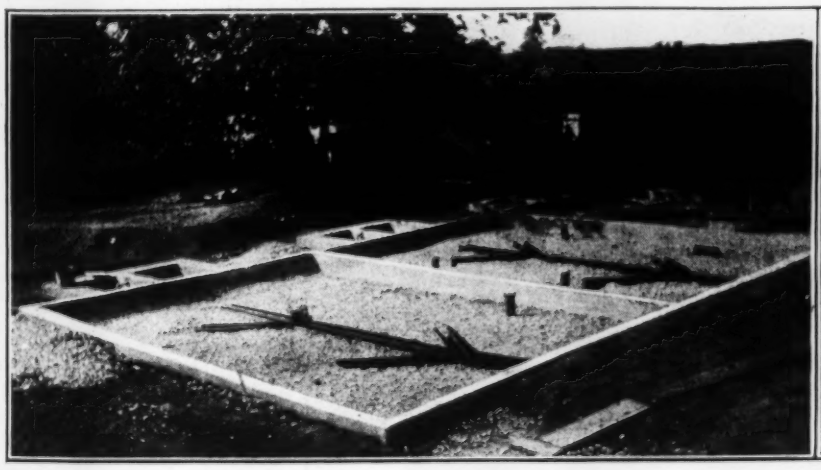


FIG. 4. CONTACT BEDS

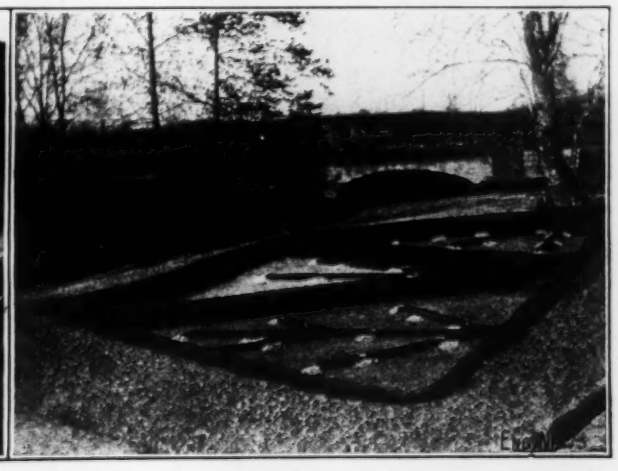


FIG. 5. SAND FILTERS

FIGS. 4 AND 5. VIEWS OF CONTACT BEDS AND SAND FILTERS, JULIETTA HOSPITAL

with asphaltum, and have notches cut out every 6 or 8 ft. Around these notches on the outside is placed broken stone (Fig. 3) so that the surface of the sand will be disturbed as little as possible.

The effluent from the sand filters is discharged into a small creek or run. The effluent is perfectly clear and without odor and no deposit of any kind has as yet been noticed.

GENERAL—Before the plant was built, the sewage had been retained in the creek immediately below the outlet until a regular septic tank had been formed which on warm days had been very offensive, a constant ebullition being always present. The appearance of the creek at this point was a black bubbling mass which if stirred with a stick would give off such a stench that it was impossible to remain near by. Further down the creek everything was coated, and small septic pools could be found for some distance below. Ducks swimming in this water died and the farmers below took the matter up with the State Board of Health, which ordered that the sewage be disposed of in some suitable manner. Since the plant has been started all nuisance has disappeared and the water in the creek is now fresh and clear. The pool just below the plant, which was formerly a nuisance, is now perfectly clear.

A large part of the construction work was done under the supervision of Dr. Potter, superintendent of the institution, by means of the inmates of the asylum who did all such work as excavation, grading, sodding and handling of material.

The plant was designed, erected and superintended by the writer.

Studies of Coefficient of Friction in Reinforced-Concrete Pipe, Umatilla Project, Oregon

By Herbert D. Newell*

The reinforced-concrete pressure pipe in use on the Umatilla Project of the U. S. Reclamation Service was described by the writer in an article in Engineering News of Feb. 16, 1911. The present article will report the results of some of these pipe lines in service.

Reinforced-concrete pipe in use are generally of two sizes, having an inside diameter of 46 and 30 in. respectively. The thickness of shell is 3 in. in each case. Both sizes were cast in a pipe yard at Hermiston, Ore., and hauled to the location of the various pipe lines. Sections of 46-in. pipe were 8 ft. long; sections of 30-in. pipe were 4 ft. long. Table I gives facts about the more important pipe lines:

TABLE I. REINFORCED-CONCRETE PIPE LINES ON UMATILLA PROJECT, OREGON

Name	Length, ft.	Maximum head, ft.	Total cost per lin.ft. laid	Date laid
46 in. inside diameter				
M	4680	55	$6.14	Winter 1907–8
O^1	5312	36	4.51	Winter 1908–9
R^2	1284	15	4.04	Winter 1908–9
R^1	9831	110	5.17	Winter 1909–10
30-in. inside diameter				
D^1	5330	45	2.69	Winter 1909–10
D	1724	22	2.68	Winter 1907–8
D	1395	35	3.51	Winter 1907–8
O^2	3556	26	2.92	Winter 1908–9
R^3	3645	25	2.43	Winter 1908–9
B	932	55	4.24	Winter 1908–9
Z	1622	18	2.31	Winter 1909–10
T^1	1398	8	2.67	Winter 1910–11
T^2	2495	18	2.83	Winter 1910–11

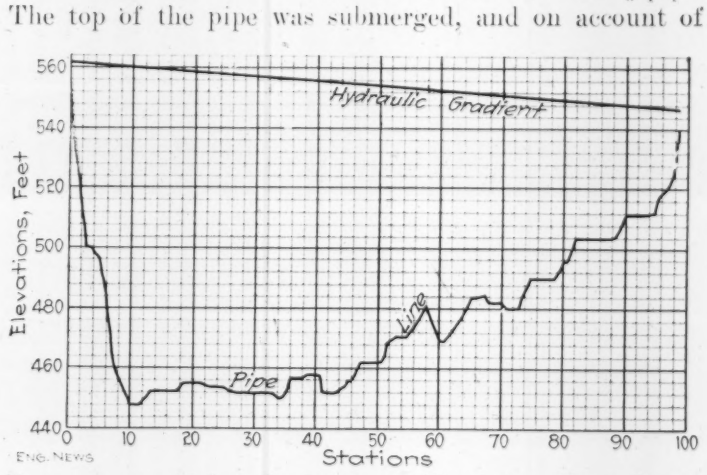
In addition, fully 8800 ft. of 12-in., 17,000 ft. of 16-in., and 4600 ft. of 20-in. cement pipe have been laid in various short pipe lines acting under moderate heads. Generally the pipe lines listed have been in use each irrigation season since they were laid. They have shown great structural strength and have proved thoroughly satisfactory. Expense for maintenance has been small.

*Project Engineer, U. S. Reclamation Service, Hermiston, Ore.

During 1911 and 1912 a number of experiments were made to determine the coefficient of friction. The R_1 pipe seemed best adapted for experiments on 46-in. pipe, and the D_1 and R_3 pipes the most favorably situated for experiments on 30-in. pipe. A profile of the R_1 pipe is reproduced herewith. The quantity of water was generally determined by meter measurements. Differences of water surface elevation between the inlet and outlet ends were determined from bench marks carefully established on the inlet and outlet structures.

The quantity of water flowing through the R_1 and D_1 pipes was so small that they were not filled for some distance beyond the intakes. In order to determine the elevation of the water surface at the inlet end a ¾-in. valve was attached to the pipe and by means of a rubber hose the elevation was determined at which the water surface came to a level in a pail. This method was used in all experiments carried on in 1911. No difficulty was experienced in determining the water surface elevation at the inlet of the R_1 pipe. The determination was less exact for the D_1 pipe.

During 1912 a testing gage was substituted for the rubber hose and its readings were used to determine the elevation of the water surface. On July 27 the elevation of the water surface at the intake of the R_1 pipe was found to be 556.44 when determined by the hose and pail and 556.36 when determined by the pressure gage. The close agreement seems to check the accuracy of both methods. No difficulty was found in determining the water surface elevation at the intake of the R_3 pipe. The top of the pipe was submerged, and on account of



Profile of 46-In. Reinforced-Concrete Pipe Line, Umatilla Project, Ore.
(Bottom of pipe)

the low velocity water entered the pipe quietly, there being no boils or eddies.

46-in. Concrete Pipe

The R_1 pipe has an inside diameter of 46 in., a total length of 9831 ft., and is subjected to a maximum head of 110 ft. It was first filled on Feb. 28, 1910. Two hours and 40 minutes after water first entered the pipe it passed out of the far end. The line was in constant use from April 1 to the end of October. During the winter water was out of the pipe except in the lowest depressions. Water was admitted into the pipe the latter part of March, 1911, and the pipe was in service until the end of October. Water was again admitted in the pipe on April 1, 1912, and the line was constantly in use until Oct. 25, 1912. Conditions are favorable for a good meter meas-

urement within 100 ft. of the intake of the R_1 pipe. Tests of observation data follow:

The cross-sectional area of a 46-in. pipe is 11.541 sq.ft.; the wetted perimeter 12.043 ft.; and the hydraulic radius, 0.96.

July 31, 1911:

Quantity of water entering pipe 46.15 sec. ft., single meter measurement.

Water surface elevation at intake	554.37
Water surface elevation at outlet	545.84
Difference	8.53

Charge friction loss against 9800 lin.ft.
Slope, 0.00087.
In formula $v = c\sqrt{rs}$ c was found to be 138; n in Kutter formula was 0.011.
Conditions were favorable while experiment was in progress.

August 23, 1911:

Quantity of water entering pipe 45.90 sec.ft.; average of two meter measurements, 45.63 and 46.12 sec.ft., respectively.

Water surface elevation at intake	553.50
Water surface elevation at outlet	545.82
Difference	7.68

Charge friction loss against 9800 lin.ft.
Slope, 0.00078.
In the formula $v = c\sqrt{rs}$ c was found to be 145; n in Kutter formula was 0.0106.
Conditions were favorable while the experiment was in progress.

June 13, 1912:

Quantity of water entering pipe 48.16 sec.ft.; average of three meter measurements, 48.84, 48.16, and 47.49 sec. ft., respectively.

Water surface elevation at intake	556.93
Water surface elevation at outlet	546.32
Difference	10.61

Charge friction loss against 9800 lin.ft.
Slope, 0.00108.
In the formula $v = c\sqrt{rs}$ c was found to be 130; n in Kutter formula was 0.0117.
Conditions were favorable while the experiment was in progress. It is probable the flow was obstructed somewhat by a small deposit in the first low depression.

July 27, 1912:

Quantity of water entering pipe 48.59 sec.ft.; average of three meter measurements, 48.32, 49.82, 47.66 sec.ft., respectively.

Water surface elevation at intake	556.40
Water surface elevation at outlet	546.37
Difference	10.03

Charge friction loss against 9800 lin.ft.
Slope, 0.00102.
In the formula $v = c\sqrt{rs}$ c was found to be 135; n in Kutter formula was 0.0113.
Conditions were favorable while experiment was in progress. Efforts made between June 13 and July 27 to remove some of the deposit by means of a fluctuating flow appear to have improved conditions.

30-IN. REINFORCED-CONCRETE PIPE

8. The cross-sectional area of a 30-in. pipe is 4.909 sq.ft.; the wetted perimeter, 7.854 ft.; and the hydraulic radius, 0.625.

July 31, 1911—D_1 Pipe:

Quantity of water entering pipe, 17.70 sec.ft., weir measurement.

Water surface elevation at intake	490.24
Water surface elevation at outlet	484.76
Difference	5.48

Charge friction loss against 5130 feet.
Slope, 0.00107.
In the formula $v = c\sqrt{rs}$ c was found to be 140; n in Kutter formula was 0.0103.

August 23, 1911—D pipe:

Quantity of water entering pipe 16.62 sec.ft., single meter measurement, 17.04 weir measurement.

Elevation of water surface at intake	490.55
Elevation of water surface at outlet	485.15
Difference	5.40

Charge friction loss against 5130 feet.
Slope, 0.00105.
Using Q = 16.62, c = 132; n = 0.0108.
Using Q = 17.04: c = 135; n = 0.0106.

June 6, 1912—R_3 pipe:

Quantity of water passing out of pipe 13.38 sec.ft., average of three meter measurements, 13.42, 12.76, 13.02 sec.ft., respectively; +.32 sec.ft., discharge over weir.

Water surface elevation at intake	543.42
Water surface elevation at outlet	540.29
Difference	3.13

Charge friction loss against 3658 lin.ft.
Slope, 0.00086.
In the formula $v = c\sqrt{rs}$ c was found to be 118; n in Kutter formula was 0.0119.
It is not unlikely that there is a considerable deposit of sand in the first low depression. Definite report cannot now be made on account of the presence of water inside the pipe.

16-IN. CEMENT PIPE

Certain experiments were also made to determine friction loss in pipe, made in sections 2 ft. long, having an inside diameter of 16 in. The data secured were:

The cross-sectional area of a 16-in. pipe is 1.396 sq.ft.; its wetted perimeter 4.189; and the hydraulic radius, $\frac{1}{3}$.

June 11, 1912—Z_a pipe:

Quantity of water entering pipe 3.74 sec.ft.; average of two meter measurements, 3.78 sec.ft. and 3.70 sec.ft.

Elevation of water surface at intake	539.14
Elevation of water surface at outlet	536.47
Difference	2.67

Charge friction loss against 700 lin.ft.
Slope, 0.0038.
In the formula $v = c\sqrt{rs}$ c was found to be 75; n in Kutter formula was 0.0154.

Aug. 22, 1912:

Quantity of water entering pipe 4.87; average of three meter measurements, 4.97, 4.78 and 4.86 sec.ft.

Water surface elevation at intake	539.60
Water surface elevation at outlet	536.44
Difference	3.16

Charge friction loss against 700 lin.ft.
Slope, 0.0045.
In the formula $v = c\sqrt{rs}$ c was found to be 90; n in Kutter formula was 0.0134.

Aug. 22, 1912—C_e:

Quantity of water entering pipe 3.42 sec.ft.; average of two meter measurements 3.65 and 3.19 sec.ft. Difference between water surface elevation at intake and outlet is 1.71 ft.
Charge friction loss against 909 lin.ft.
Slope, 0.00188.
In the formula $v = c\sqrt{rs}$ c was found to be 98; n in Kutter formula was 0.0125.

Discussion of Measurements

Examination of the R_1 pipe at the end of the season showed the interior to be smooth and generally in good condition. There was a small deposit of gravel just beyond the first depression, possibly one-half cubic yard of material was removed. There was a little gravel at other places, but in general the interior presented an excellent appearance.

In the D_1 pipe beyond the first depression there was a deposit about 75 ft. long and 0.5 ft. thick. About 1.5 cu.yd. of material were removed from the deposit. There were a few other small deposits, but generally the interior of the pipe was smooth and presented an excellent appearance.

There is probably some deposit in the R_3 pipe. An examination is not yet practicable because of the presence of water, which it is not feasible to remove. No information exists as to whether or not the 16-in. pipes are somewhat obstructed by deposits near the bottom of depressions.

It will be noted that the 16-in. pipe show discharges relatively much smaller than the 30- and 46-in. pipe. The 16-in. pipe are made by the dry process and have joints every 2 ft. At every joint there is unavoidably a slight irregularity in the cross-section. The mixture used in making the 30- and 46-in. pipe is distinctly a wet mixture. All sizes are grouted on the inside, but the grouting on the large sizes is more smooth, as a man can work inside the pipe and it is possible to do a better job. A summary of results is shown below:

TABLE II. SUMMARY OF RESULTS OF FRICTIONAL STUDIES OF REINFORCED-CONCRETE PIPE, UMATILLA PROJECT, OREGON

Description	Date of experiment	Slope	Velocity	c	n	Remarks
R^1 pipe	July 31, '11	0.00087	4.00	138	0.0111	Cond. favorable
Dia., 46 in.	Aug. 23, '11	0.00078	3.98	145	0.0106	Cond. favorable
Length 9831 ft.	June 13, '12	0.00108	4.17	130	0.0117	Cond. favorable
Max. hd. 110 ft.	July 27, '12	0.00102	4.21	135	0.0113	Cond. favorable
D^1 pipe	July 31, '11	0.00107	3.61	140	0.0103	Cond. fair
Dia., 30 in.	Aug. 23, '11	0.00105	3.39	132	0.0108	Cond. fair met. meas.
Length 5330 ft.	Aug. 23, '11	0.00105	3.47	135	0.0106	Cond. fair weir meas.
Max. head 45 ft.						
R^3 pipe:						
Dia., 30 in.						
Length 3645 ft.	June 6, '12	0.00086	2.73	118	0.0119	Cond. favorable
Max. head 25 ft.						
Z_a pipe*:						
Dia., 16 in.	June 11, '12	0.0038	2.68	75	0.0154	Cond. fair
Length 700 ft.	Aug. 22, '12	0.0045	3.49	90	0.0134	Cond. fair
Max. head 9 ft.						
Z_c pipe*:						
Dia., 16 in.						
Length 909 ft.	Aug. 22, '12	0.0019	2.45	98	0.0125	Cond. favorable
Max. head 18 ft.						

* Cement pipe.

Twin-Screw Motor-Ship "Hagen"—A New Krupp Two-Stroke Type Diesel-Engine Tank Vessel of 2,400 B.Hp.

By J. Rendell Wilson*

The highest-powered two-stroke-cycle Diesel-engine vessel yet launched, the new Krupp-engined motor-tank ship "Hagen," which has just carried out successful trials, should have particular interest for all connected with engineering, especially as the difficulties in connection with the design and construction of high-powered marine Diesel engines have been enormous, and more especially because the evolution has all practically been carried out in a couple of years and not the half-century taken to develop the marine steam engine.

Fig. 1. The Largest Diesel Oil-Engine Vessel Afloat. The Tank Ship "Hagen," Built for the German-American Petroleum Co., by Fried. Krupp, Kiel, Germany

Although there are now three other motor ships in service of equal power, all are driven by Diesels of the four-stroke type and the next in size to the two-stroke motor ship "Hagen" is the Hamburg-American Co's ship "Monte Penedo," which is fitted with two Sulzer-Diesel engines each of 850 b.hp. Seeing that each of "Hagen's" motors have given as much as 1500 brake horsepower on test, the advance is noteworthy considering the present stage of the development and she may thus be called the highest-powered motor ship afloat.

There is much doubt among shipowners and their marine superintendents as to which is the superior type of Diesel motor for merchant vessels. At the present moment there are 33 motor vessels building, with four-stroke engines having a total power of 61,500 b.hp., as against 20 ships with a two-stroke engine-power of 34,250 b.hp., while out of 75 vessels in service only 30 have two-stroke motors. I am speaking now only of craft of over 100-ft. length.

There are, however, now twice as many engineering firms constructing two-stroke Diesels as there are building four-stroke Diesels, so it is rather difficult to see as yet what the future type will be. For naval work there can be no doubt that the two-stroke Diesel will be adopted as the standard engine. The auxiliary engines of all motor ships in service are of the four-stroke class—a noteworthy point.

Although the "Hagen" is the first large motor ship turned out from Messrs. Krupp's Germania Yard at Kiel-Gaarden, it must not be thought that this vessel is purely an experiment, as for years they have been building Diesel engines for submarines and other naval craft, and only recently they succeeded in obtaining as much as 2700 b.hp. on the experimental test bed from a single-cylinder double-acting two-stroke motor, the highest power yet obtained from one cylinder.

The "Hagen" is the first of three vessels (two sister ships and one of 15,000 tons) building for the German-American Petroleum Co., and by the time this appears in print she should be in American waters on her maiden voyage. Her trials were carried out on Mar. 12, and were very successful, a speed of well over 12 knots being attained, the contract speed being 11 knots. She is 400 ft. long between perpendiculars, by 49 ft. beam, with a molded depth of 32 ft., and her deadweight carrying capacity is 8350 tons on a draft of 23 ft., while her gross tonnage is 7770 tons. She has been built by Krupps to the English Lloyds' 100 A. 1. Class, and to the German Lloyds' 100 A. 4. Class, and will be used for carrying oil in bulk, the oil being divided into a number of tanks by transverse bulkheads subdivided by a longitudinal bulkhead extending the whole length. Partly to

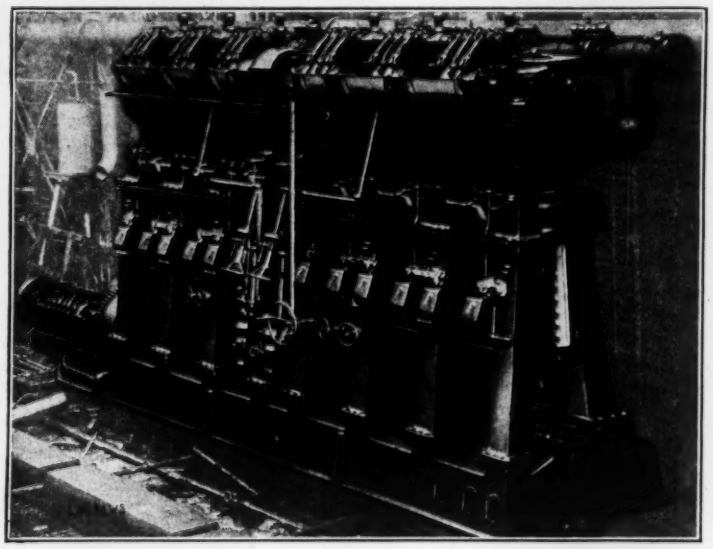


Fig. 2. One of the Six-Cylinder Two-Stroke-Cycle Diesel Oil Engines for the Tank Ship "Hagen"

conform with freeboard rules, which vary with the seasons, and partly to increase the loading capacity when cargo capacity of a lower specific weight is being carried, there are what are termed "summer" tanks arranged alongside the expansion hold, which runs the entire length. The engine exhaust gas is carried to a slender funnel.

But it is the machinery and not the hull which forms the most interesting part of the ship. There are two main engines, and two auxiliaries, the latter being of 250 b.hp. each, and an oil-fired donkey boiler and steam engine for driving a spare compressor set. The total weight of the machinery, shafting and propellers is 580 tons, of which the main engines represent 280 tons, or less than half. Each of the main engines is of the two-stroke, single-acting, direct-reversible type, and has six

*66a, Great Portland St., London, England.

cylinders 19-in. bore by 32-in. stroke and develops 1200 b.hp., or about 1500 i.hp. at 135 rev. per minute. The rated horsepower is 1125 b.hp. Each engine is grouped into sets of three cylinders for the purpose of easy control, so that any three cylinders can be kept running under load, and the others "cut out," thus reducing the engine speed to about 30 r.p.m. This, of course, is a valuable feature when navigating crowded harbors, as the speed of the vessel is then very low.

The general operation of the two-stroke Diesel engine is now so well known that it hardly needs dealing with here; but perhaps the mechanical details of the Krupp engine can be followed easier if this is briefly given. On the upstroke of the piston, atmospheric air is compressed to about 450-500 lb. per sq.in. in the cylinder head, generating an enormous heat, and just before the top of the stroke a charge of oil-fuel is injected by an air blast of 850-950 lb. per sq.in., which also thoroughly atomizes the fuel. Combustion instantly takes place and lasts as long as the fuel is being injected. At the bottom of the stroke the exhaust ports are uncovered by the piston, and at the same time the scavenging valves open and a charge of air from a pump delivering at about 4 lb. per sq.in. clears the cylinder of all exhaust gases, leaving it filled with pure air to be compressed on the next upstroke and then this cycle is repeated.

The port engine of the "Hagen" has all its controls arranged on its starboard side, and the starboard engine has its on the port side, so that the two engines form a gangway, between which are arranged the controls and the telegraphs. On the opposite side to the control side

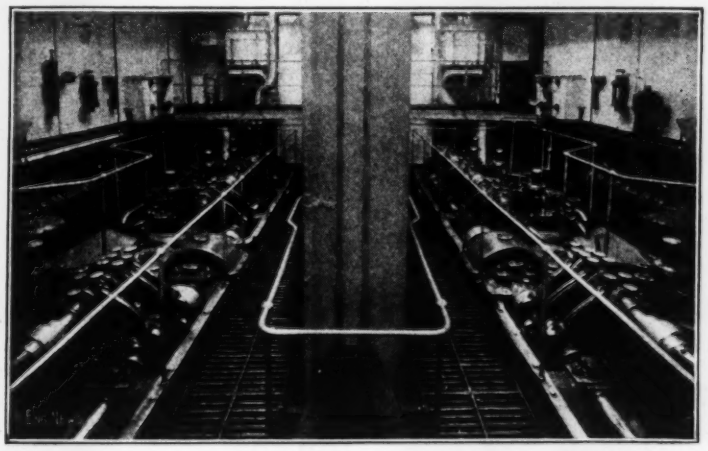


FIG. 3. VIEW OF THE ENGINE ROOM OF THE "HAGEN," SHOWING SCAVENGING VALVE LEVERS

are arranged the scavenging air pumps, one to each set of three cylinders. They are driven by means of levers off the connecting-rods of the engines. It will be seen that the motors are of the open type, with crossheads and guides; but have trunk pistons, which are water cooled, while the cylinders are mounted on cast-iron box columns set at an angle to each other. This arrangement differs somewhat from the Werkspoor-Diesel marine engines, which have vertical steel columns. In the "Hagen's" engines the lower ends of the columns are bolted to a heavy box-type cast iron bed-plate, which is made in three sections.

The scavenging air enters through two valves in each cylinder head. There is a tendency among marine oil engine designers to dispense with scavenging valves altogether, as too many valves weaken the cylinder head, also the valves give trouble. The Junkers-Diesel engine has only air-starting and fuel-injection valves, scavenging and exhaust being entirely by ports in the cylinder. There are two other valves in the cylinder head, one for admitting air for starting and reversing, the other for the injection of fuel. All valves are of the mushroom type and are operated by rocking levers mounted on the cylinder heads by means of cams on a camshaft running the length of the engine. The camshaft is, however, constructed in two lengths, and can be disconnected should a breakdown occur to one set of three cylinders. The rocking levers operating the valves, are mounted eccentrically on a steel shaft in order that their rollers can be lifted clear of the cams when reversing, etc. A hand wheel controls the lifting of the rocking levers when maneuvering.

Reversing is simply carried out by shutting off the fuel, raising the valve-rocking levers clear of their cams, sliding the camshaft endwise, bringing in another set of cams into action. Then compressed air is admitted to the pistons on the upstroke through the starting valve, thus reversing the motion of the crankshaft, when the fuel valves again come into operation. A small hand-controlled compressed-air engine is used for carrying out the maneuvering, but hand controls are also fitted. When maneuvering, three cylinders are generally allowed to run on air until the other three have taken up the load on fuel, in reality a brief operation. When starting, air pressure in the cylinders is relieved by an independent lever holding up the air valve.

Fuel is supplied to the injection valves by means of six plunger pumps to each engine, the suction valves of which are controlled by levers from the control platform, thus the engine speeds are easily varied, or entirely shut off as desired. The suction valves are also controlled by a governor. The fuel consumption is 6.35 oz. or just short of 0.4 lb. per b.hp. per hour, or about $5\frac{1}{10}$ tons per 24-hr. day per engine.* Lubrication of the engines is by a number of pumps which supply the cylinders, bearings, etc. Too much lubricating oil is a thing to be avoided with Diesel engines, and the consumption is very low. The water circulating pumps are driven off the main engines as is a two-stage compressor for supplying air to the steering engine. There are two three-cylinder Krupp Diesel engines of the non-reversible four-stroke type, each of 275 b.hp. which drive the auxiliary plant, including the main air compressors, which charge large steel storage bottles. This machinery is arranged at the forward end of the engine room. On the trials the fuel used was gas-oil, but, of course, much heavier oil could be used if necessary. The fuel-tank capacity is 500 tons. Her engine-room staff consists of twelve men and no stokers, as against 24 engineers and greasers in a steamship of the same size.

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The Total Income of American State Universities and colleges during 1912, is placed at about $35,000,000 in a recent bulletin of the Federal Bureau of Education. These figures embrace only the 87 institutions which are in part or wholly supported by government funds. Of the above sum $5,000,000 was contributed by the federal government, $18,000,000 by the state governments and the balance by private subscription. The institutions having the largest income are the state universities of Illinois, Minnesota, Wisconsin, Michigan, Ohio and California, and Cornell University in New York State.

*This consumption is higher than that of the motor ship "Selandia," whose two 1250-b.hp. four-stroke engines together consume 9½ tons per 24-hr. day.

Western (Asphaltic) Oils not Effective Waterproofing Agents for Concrete

Some two years ago Logan W. Page, Director of the U. S. Office of Public Roads, announced* a series of tests, made by his office, which tended to show that certain petroleum residuum oils will mix uniformly with concrete or cement mortar, forming what may be termed an emulsion, and that concretes and mortars thus mixed with certain percentages of oil are "absolutely watertight under pressures as high as 10 lb. per sq.in." and "under low pressures, both are waterproof." In a paper† before the American Society of Civil Engineers, Messrs. Arthur Taylor and Thomas Sanborn, of Leland Stanford, Jr., University, present the results of some tests which show that the watertight properties of oil-mixed concrete do not extend to concretes mixed with the western oils which are high in asphaltum. While Mr. Page's paper did not state that these high asphaltum oils would not give the results which he noted, it did state that certain specifications (to which the California oils would not conform) give good results.

We give below Mr. Page's specifications and some extracts from the later paper. The main point to note is that any mineral oil is not necessarily a safe or desirable material to mix with concrete.

EXTRACT FROM L. W. PAGE'S PAPER

For oil-mixed concrete, petroleum residuum oils conforming to the specifications given below have been found to give good results in both laboratory and service tests.

(1) The oil shall have a specific gravity of not less than 0.930 nor greater than 0.940 at a temperature of 25° C.

(2) It shall be soluble in carbon disulphide at air temperature to at least 99.9%.

(3) It shall contain not less than 1.5 nor more than 2.5% of bitumen insoluble in 86° B. paraffin naphtha.

(4) It shall yield not less than 2.5 nor more than 4% of residual coke.

(5) When 240 c.c. of the material is heated in an Engler viscosimeter to 50° C. and maintained at that temperature for at least 3 min., the first 100 c.c. which flows out shall show a viscosity of not less than 40 nor more than 45.

(6) When 20 grams of the material is heated for 5 hours in a cylindrical tin dish 2½ in. in diameter by 1 in. in height, at a constant temperature of 163° C., the loss in weight shall not exceed 2%.

EXTRACTS FROM PAPER BY MESSRS. TAYLOR AND SANBORN

It was found, as stated by Mr. Page, that the western (asphaltic) oils will also readily emulsify with wet cement, cement mortar, or concrete, and can become mixed so thoroughly in the mass that on examination with a reading glass no unassimilated globules of oil are visible. The mixture has a rich glossy appearance; the oil, apparently, has spread itself out in a thin film enveloping each particle of sand and rock. Even a very thick oil—one which is so viscous that when cold it cannot be poured—will mix and disappear in concrete or mortar when it is heated and mixed with hot aggregates. The amount of mixing was found to be a principal factor in determining whether or not the oil is incorporated completely and uniformly with the other ingredients of a mortar or concrete. The consistency of the concrete or mortar also governs the degree of emulsification; the wetter the mixture the better the oil emulsifies.

The oils used were commercial products having trade names as indicated at the top of the next column.

The following conclusions are drawn from the results of the investigations:

1. Oil-mixed concrete containing 5, 10, or 15% of oil, by weight of cement, is more permeable under pressures from 20 to 60 lb. per sq.in., than concrete without the incorporated oil, and oil-mixed mortar containing 10% of oil

MECHANICAL ANALYSIS OF OILS

Name	Baumé gravity	Flash point, deg. F.	Burns, deg. F.	Asphaltum %
Boiler fuel	17°	174°	....	42
Richmond Road Oil No. 6	13°	260°	400°	75
Richmond fuel	16°	210°	300°	52
Star fuel	24°	195°	245°	21
Liquid asphalt	0°.9	....	....	92

is more permeable than plain mortar under pressures of 10 and 20 lb. per sq.in.

2. Oil-mixed mortars containing percentages of oil up to 25 show slightly les absorption of water than plain mortar, except that with the most viscous oils the water becomes more absorptive, and absorption is not an index of the permeability. The absorption decreases with the increase in the quantity of oil.

3. The tensile strength of oil-mixed mortar is decreased considerably below that of plain mortar. The strength decreases with the increase in the quantity of oil.

4. The compressive strength of oil-mixed mortars follows lines similar to those of the tensile strength, but with a greater decrease in the strength with the quantity of oil.

5. The strength decreases with the viscosity of the oils, and with the most viscous oils it requires considerably more water to keep a mixture at normal consistency than is required in the fluid oil mixtures.

6. The relative decrease in strength with the increase in the quantity of oil in mortars is less in 50 than in 28 days.

*Engineering News, Oct. 12, 1911, p. 440.

†"Some Experiments with Mortars and Concretes Mixed with Asphaltic Oils," by Arthur Taylor and Thomas Sanborn. "Proceedings," American Society of Civil Engineers, March 1913, p. 355. Presented April 16, 1913.

Progress in San Francisco Transportation Improvements

The Board of Supervisors of San Francisco recently invited B. J. Arnold, who has been retained to report on the improvements needed in the entire transportation system of the city, to sum up the results of his investigations prior to making a final report. In Mr. Arnold's absence this was done in an address by his resident engineer, J. R. Bibbins.

It was first reviewed how the deficiencies in San Francisco street plan and the topographical difficulties to reaching the outlying peninsular districts were responsible for restricting population to about one-half the total city area. This had resulted in a development of suburban territory across San Francisco Bay in the cities of Oakland, Berkeley and Alameda. Through the construction of the Twin Peaks Tunnel and other outlets (see ENGINEERING NEWS, June 20, p. 1203 and Dec. 5, p. 1054, 1912), the 30-minute zone would be extended to include land now available for such residential districts.

The city's street railway lines were held to be 6 years behind in extensions so that it was necessary to follow some program for the construction of 70 miles of sigle track. These extensions had been carefully planned after a study of every grade in the city, and its relation to the location of the population and possible transit lines. The program mapped out calls for about 15 miles of track to be laid per year up to 1920, and from 40 to 50 additional cars per year.

Statistics showed that the average inhabitant of San Francisco pays twice as much for street railway transportation per annum as in other cities of this class. This amount ($20 per capita) exceeds the taxes assessed for municipal government.

The city has more than regained the population it had before the recent fire and earthquake, and the exodus to the trans-bay cities has ceased, so that the peninsular communities will continue their rapid growth. It was recommended that all the cities on the peninsula should be united as a metropolitan district for the control of

such matters of common interest as transportation, water, police, etc.

Mr. Arnold has predicted a population of 1,000,000 for San Francisco within 25 or 30 years. The purchasing power of the city, based on its present debt limit, will not keep pace with the necessary investment for transportation facilities; and the disparity is so great that, even were the city now entirely free from debt, it would require about one-third of the city's entire bonding power continually. This point proves the necessity of encouraging the investment of private capital in street railways unless the city can raise its debt limit. The possibility of assessing on the cost of real estate traction extensions was mentioned.

It was reported that the traffic manager of the Panama Pacific Exposition has confirmed the ideas of Mr. Arnold on the facilities needed for this project. The expected peak load of 50,000 passengers per hour exceeded the total outbound traffic from the business section during the evening rush hours. Principal among the features of any plans proposed, uninterrupted and rapid service should be provided during the most congested periods by leaving a free way for vehicles to pass between cars and any vehicles standing along the curb.

In comparing types of cars, the new municipal equipment (Geary St. line) was held to combine comfort with capacity, quick loading, and increased safety. This type of car can accommodate double its seating capacity, or a maximum of 100 to 110 passengers, without interfering with passenger movement. It was held that the present equipment of the United Railroads could be improved 25% by modifications in platform arrangement such as the removal of bulkheads, straightening of guide railing, and the conversion of earlier types into prepayment forms.

Much of the congestion around the city was found to be due to slow loading on Market St. and at the ferry, and to inadequate terminal facilities.

It was reported that the inner tracks of the four-track system on Market St. had about reached their capacity, so that future additional traffic must be diverted from this street and loops and subterminals provided elsewhere in the vicinity of the ferry. The use of tandem stops, with two cars crossing intersecting streets together, had already produced improvement.

The adoption of a resettlement plan with indeterminate franchises, as exemplified in Chicago Charter Amendment 34, was urged for the ultimate organization of transit facilities in San Francisco. In accordance with such a plan it was held that both tangible and intangible values would be retired by the company, adequate service would be continuously secured, extensions would be built as required, the lines would be continuously maintained at the highest standard, and the city could take over the property when ready to do so at far less cost than it could build an entirely new system.

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Collapse of a Large Steel Pipe

A steel pipe, 14 ft. in diameter, connecting two reservoirs of the Balleville Hydroelectric Co., near Fremont, Ohio, recently collapsed, while being filled with water. The views herewith show the nature of the failure and give some idea of the construction and arrangement of the pipe. Examination of the design shows that the pipe was entirely inadequate to withstand the distorting effect of the weight of water contained in the pipe, and that it was bound to fail.

The construction of the pipe is described in *Power* of Mar. 18, 1913. The pipe sheet was $\frac{5}{16}$ in. thick. The individual rings were 6 ft. 8½ in. long, and over the joints were stiffening rings, each consisting of one 6x4x$\frac{3}{8}$-in. angle (presumably with 6-in. leg outstanding).

FIGS. 1 AND 2. TWO VIEWS OF COLLAPSED 14-FT. STEEL PIPE AT BALLEVILLE, OHIO

These angle rings were spliced at the horizontal diameter by splice plates 15 in. long.

The pipe was supported every 14 ft. along its length by two concrete piers 2x2 ft., spaced 6 ft. apart transversely, capped with steel shoes.

When the pipe was about full, a length of some 600 ft. collapsed in the way the views show, starting at a point 200 or 300 ft. below the headgate. The angle stiffening rings broke at the splice on the horizontal diameter and the outstanding legs buckled at the top of the pipe.

The pipe is about 3000 ft. long, extending along the west bank of the river. It is required to carry only a small hydrostatic head. The power plant which it supplies is equipped to generate 6000 kw. from the flow of the Sandusky River, stored by a dam at Balleville, about three miles above Fremont.

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The River Harbors of Europe are the subject of a report just submitted to the City Planning Commission of Pittsburgh by its consulting engineer, Kenneth C. Grant. Mr. Grant spent the summer of 1912 studying the principal water terminals on the chief rivers of Europe. His report to the Commission includes plans and recommendations for the development of the Pittsburgh waterfront along the Monongahela and Allegheny Rivers to secure the combined ends of flood protection and terminal facilities.

An Articulated Street Car

The Boston Elevated Ry. Co. has two articulated surface cars of the type shown in Fig. 1 in service on a crosstown line, which lies almost entirely within a residential district, containing a few small shops and a number of schools and halls. There were several transfer points on this line and these cause a heavy short-haul traffic. It was thought possible to design a car which would hold as many people as the standard cars of the company and still run on narrow streets and around sharp curves without objectionable overhang. The designers sought to find some use for the 1400 odd small cars which the company possessed, and considerations of convenience and safety to entering passengers also had weight.

As is evident from Fig. 1, one vestibule and platform were removed from two of the old 20-ft. closed cars which were then connected by an intermediate section to form a single unit 62 ft. 10 in. long over bumpers. The car shown has the intermediate-section floor 14 in. above the roadway giving a "stepless" exterior design. As may be seen from Fig. 2, the entering passenger, after depositing his fare, has to take a second step of 10 in. to approach either riding section. The second platform he then stands on has a rise of 2 in. between its outer edge and the final step up (5 in.) into the car proper. On the ends of the old frames are fastened the bolster shown in Fig. 3, and this has rollers on which the bearing plate of the intermediate frame rests. The channel-section center sills of this frame drop below the bolster-frame level and carry the side-sill angles through three channels, resting on the bottom flange, held in place with reinforcing plates and stiffened with diagonal angles.

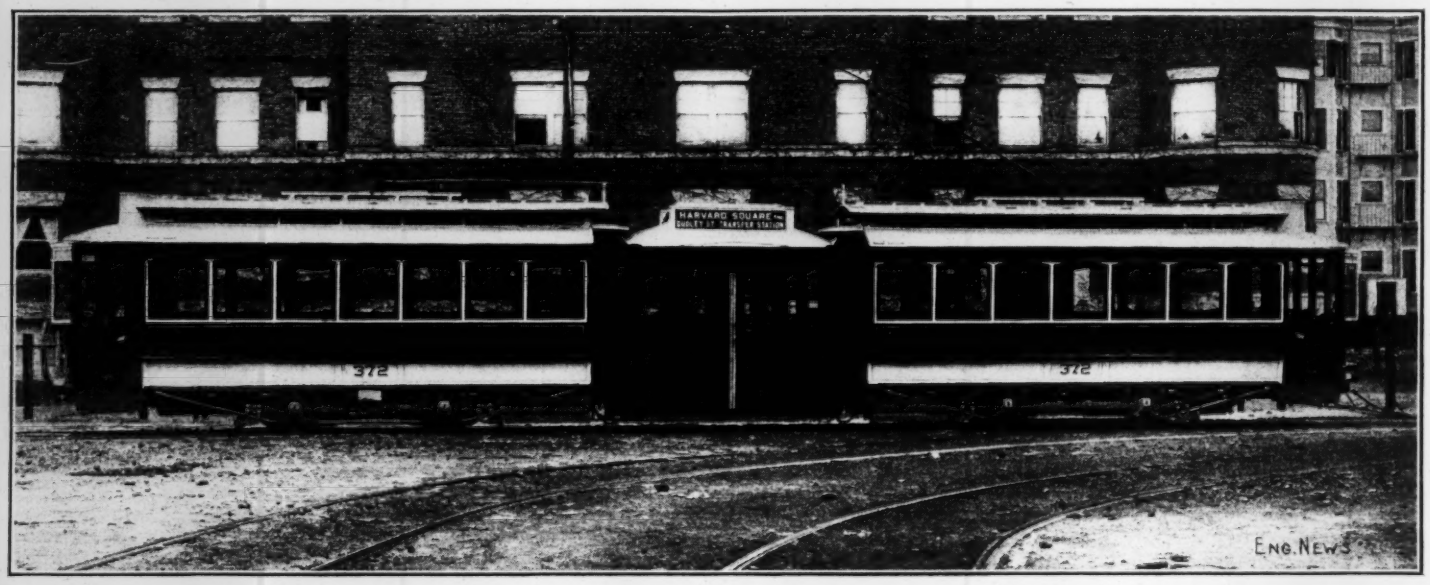


FIG. 1. ARTICULATED TYPE OF SURFACE CAR; BOSTON ELEVATED RY. CO.

FIG. 2. CENTER SECTION OF BOSTON ARTICULATED CAR

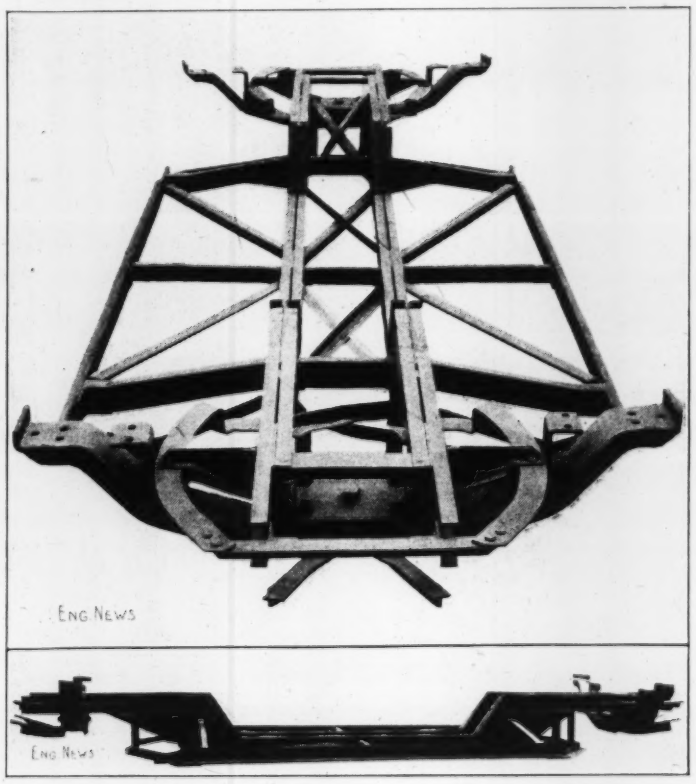


FIG. 3. END AND SIDE VIEWS OF CENTER-SECTION FRAME; BOSTON ARTICULATED CAR

A flexible waterproof curtain incloses the passageway between the center and end compartments. The roof extensions of the end sections, which project over the en-

trances from the center section, have a horizontal hinge and rest on the center section roof.

The conductor's station, of course, is on the center section. Near the fare box are push-buttons governing bells in the front and rear vestibules to signal the motorman in whichever end happens to be forward. In the center section are four 500-watt electric car heaters. All passengers, of course, have to enter by the center section, but the passengers in the forward section leave through the four vestibule doors which are opened by the motorman. A folding step drops with the opening of the vestibule doors. The car has semi-automatic air brakes with an emergency valve at the conductor's station. The center doors are operated by compressed-air cylinders near the roof instead of at the floor as is common. The company reports that the average boarding and leaving time on these cars is about 2 sec.

The Westinghouse-Leblanc Water Vapor Refrigerating Machine

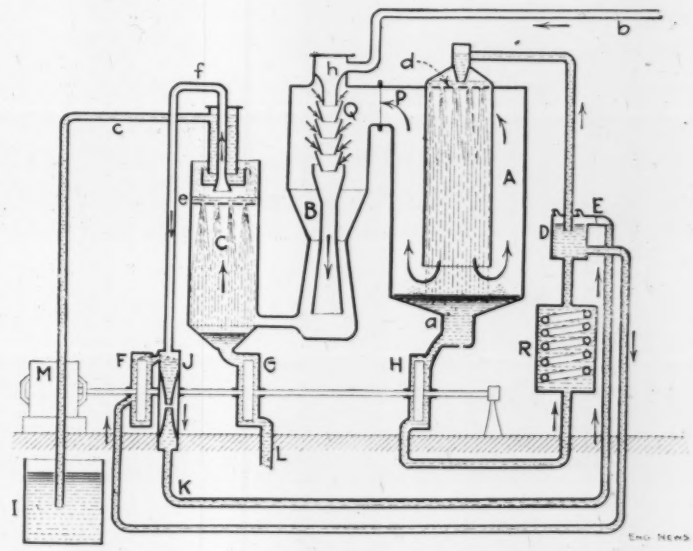
By H. J. Macintire*

Mechanical refrigeration has shown great progress in the last decade and now is used in almost every industry where rapid cooling is required. A number of refrigerants have been used for mechanically securing low temperatures. In the early days air was employed, the approximate adiabatic expansion of which gave the desired low temperature. The air machine, however, is bulky and has a low efficiency so that recourse is made to the use of a vapor of suitable boiling temperature. Of the number of theoretically possible refrigerating vapors carbon dioxide, sulphur dioxide and ammonia alone are used; the last being the favorite in America.

In America, ammonia is employed for about 95% of the total refrigeration, whereas, in England, France and Germany, carbon dioxide is used to a much greater extent. Refrigeration on board ship, in mines, hotels and other confined quarters, where the liberation of a noxious gas would be serious, makes the problem of selecting an appropriate refrigerant of even greater importance. None of the three vapors mentioned are innocuous to man, although carbon dioxide is most nearly so However, the pressures carried with this last, frequently 1000 to 1200 lb. per sq. in., are excessive and explosions are not unknown. This danger is recognized in the French navy, which has limited the size of the units used in their ships. The U. S. Navy is still using a dense-air machine which carries a suction-line pressure of 65 lb. gage, the gas being used continuously, but these machines are never built in any but very small sizes and trouble due to freezing of the lubricating oil is encountered daily.

The most logical medium to use, the one costing least and the one which would be perfectly harmless, is water vapor. The difficult problem here is, however, in caring for the vast increase in the specific volume of steam at low temperatures; at 50° it is 1702, at 40° it is 2438, and at 32° it is 3294 cu.ft. per lb. of steam. If a compressor with a piston were used for compressing the vapor the necessary displacement of the machine per pound of vapor would have to be absurdly great. Fortunately, the same end may be obtained with high-speed rotary apparatus, or its equivalent, as is shown in the design of the Westinghouse-LeBlanc water-power machine.

The accompanying figure shows diagrammatically the arrangement of this machine. At *R* are the refrigerating coils which may be arranged to carry the cooling agent within them in the usual manner, or to allow the brine or cold water to fall in the form of a spray in contact with the air to be cooled. In the latter case some moisture is absorbed from the air, which partially neutralizes the loss of vapor in the evaporating chamber *A*. The warm brine now passes into the reservoir *D* which is subject to atmospheric pressure, and is then siphoned into the evaporator *A*, into which it falls in the form of a fine spray, after having passed the perforated plate *d*. The jet-condenser chamber is at *C*; the condensing water coming in from the cold-water supply *I* through a perforated plate *e* at the top of *C*. The condensing water and condensate are removed by means of a turbine-type pump *G* and the air and water vapor by means of the



Diagrammatic Arrangement of Westinghouse-Leblanc Water-Vapor Refrigerating Machine

rotary pump with water pistons at *F* and *J*. A vacuum of 1 lb. absolute may be obtained at *C* with cooling water of usual temperature, and in order to obtain $\frac{1}{10}$ pound absolute in *A* (corresponding to an evaporating temperature of 28-30° F.) work must be done on the vapor from *A* to compress it to the pressure in *C*. This is accomplished by means of the ejector cones *Q*, through which steam passes at high velocity, dragging with it the vapor evaporated in *A*. Either high-pressure or exhaust steam may be used, and in the latter case the electric motor *M* is replaced by a small steam turbine, and the pipe *b* conveys the exhaust to the chamber *B*. As shown, all the pump motors are on the same shaft. The level of the reservoir *D* is maintained constant by means of some kind of float and valve, which admits water at the temperature of the supply *I*.

So far in America, this machine is in but an experimental stage; its actual use has been confined to marine work abroad for the most part, a large number of installations having been made in the French Navy. For stationary work, however, its possible applications are many, and there is every reason to believe that it will soon become more widely known. Although temperatures

*Carnegie Institute of Technology, Schenley Park, Pittsburgh.

of 32° F. and lower may be obtained, its special sphere of usefulness is for temperatures of from 35° to 50°. With these latter temperatures, the economy is high, being about 400 B.t.u. of refrigeration per pound of steam supplied to the ejectors, whereas only about 200 B.t.u. is obtained at a refrigerating temperature of 25° F. As air cooling in auditoriums, banks, hotels, chocolate factories, etc., seldom requires temperatures lower than 50°, and as the installation has no element of danger on account of the harmless refrigerant, a field will probably soon open for it along these lines.

So far little information is available about the space required, but it will not be greater than that necessary for the ammonia compressor and condenser. The design is so simple that the first cost will be small and, for the uses cited, no brine should be necessary as the temperatures are safely above 32° F. There is no practical limit of size to this machine, the largest in Europe being about 350 tons, and in America about 200 tons of refrigeration.

In comparing the relative efficiencies of the water-vapor and ammonia machines, only approximate values can be given, as too many specific factors come in for a general statement. Roughly the horsepower of the ammonia compressor per ton of refrigeration varies from 0.5 to 1.2 or more which would correspond to from 15 to 30 lb. of steam per ton of refrigeration or to from about 300 to 600 B.t.u. per ton per minute, a value which is nearly, if not quite, the economy of the water-vapor machine. Considering (1) that the modern small impulse steam turbine and centrifugal pump may be run for days without attention, the cost of maintenance and operation being reduced accordingly, and (2) that the element of danger is lowered to a minimum, then this water-vapor machine would seem to compare favorably in economy with older types of refrigerating machines.

❖

The Maine Public Utility Law, recently passed and signed by the governor, abolishes the present Board of Railroad Commissioners and the State Water Storage Commission. There will be instead three commissioners to be appointed by the governor with the advice and consent of the Council. The salary of the chairman is to be $5000 a year and that of each other member $4500. The first chairman will hold office for seven years, and the other members respectively for five and three years; appointments after the first board are to be for seven years. The commission is given authority over railways and electric railways, express companies, gas, electric light and power companies, telephone and water companies, etc. The right to require books, records and witnesses is given, and corporations are required to furnish such information as is necessary. Uniform accounts are imposed under the prescriptions of the commission. Schedules of rates are to be filed and such ones as the commission orders are to be printed and opened to public inspection. Unreasonable preferences or rebates are prohibited, and competition in utilities is prohibited except where the commission deems the second one a public convenience and necessity. The commission has power to make physical valuations of property and authorize the issue of stocks, bonds and notes; no such evidences of indebtedness can be issued without the commission's permission. Selling, leasing or mortgaging public-utility property and acquiring the stock of other companies is not permitted without commission sanction. Accidents are to be reported and the commission is to investigate and make such recommendations as seem reasonable. The law fixes the details of procedure in connection with complaints before the commission. The burden of proof is placed on the party adverse to the commission or seeking to set aside a commission order. Appeal to the courts is provided on questions of law.

The governor has appointed the following members: L. B. Deasy, of Bar Harbor (Chairman), W. B. Skelton, of Lewiston, and Joseph Williamson, Jr., of Augusta. They are all lawyers with experience in corporation work.

A Rational Culvert Formula

By W. W. Horner*

The following formula for culvert size is based on the data used in sewer design in St. Louis.

Rainfall—The rainfall curve for St. Louis as used by the Sewer Department (described in Engineering News, Sept. 29, 1910, p. 326) was expressed by the formula $I = \frac{56}{(t+5)^{0.85}}$, where I is the rate of rainfall in inches per hour and t is the duration of the downpour in minutes. The runoff in cubic feet per second per acre was shown graphically and is the product of values of I for any certain time by a coefficient p (also a function of the time) the values of which were fixed arbitrarily, using the best experimental data then available.

For use in the culvert design, the rainfall curve was slightly changed to fit the simpler formula $I = \frac{30}{t^{\frac{3}{4}}}$, and the value of p was taken as, $p = 0.2 I^{\frac{1}{4}}$. The runoff per acre is then $pI = \frac{6}{t^{\frac{1}{2}}}$. Values of I, p and pI for certain values of t, as computed by this formula, are shown below:

t, minutes	I, inches per hour	p	pI, cu.ft. per sec. per acre
5	8.5	0.30	2.55
10	5.4	0.36	1.95
15	4.0	0.40	1.60
20	3.2	0.42	1.35
30	2.3	0.47	1.08
45	1.7	0.52	0.88
60	1.4	0.56	0.78
90	1.03	0.62	0.64
120	0.82	0.66	0.54
180	0.61	0.73	0.45

These values of I approximate closely those given by the above-mentioned rainfall curve for St. Louis, and should hold for Central Mississippi Valley conditions. The values of p are slightly high for open agricultural country on moderate slopes and normal soil conditions; they are too high for loose sandy soil and too low for hard-packed clay.

Derivation of Culvert Formula—It was decided that the culvert formula should be expressed in terms of the drainage area A in acres, the length of watercourse L in feet, and the average slope of the stream bed S in rate of grade (total fall divided by length of stream).

To attain this result, the following equations were used:

$$\textit{The total runoff } Q = ApI = \frac{6A}{t^{\frac{1}{2}}} \qquad (1)$$

Assume the cross-section of the channel to be a semicircle of radius r, the channel being at all points along the stream just sufficient to carry the flow. Using the exponential formula for flow of water $V = CR^{0.67} S^{0.54}$ in the simplified form $V = CR^{\frac{2}{3}} S^{\frac{1}{2}}$ where R will be $\frac{r}{2}$ and C is taken as 80 (for fairly uniform natural channels).

$$V = 50.0\, r^{\frac{2}{3}} S^{\frac{1}{2}} \qquad (2)$$

and

$$Q = 78.5\, r^{\frac{2}{3}} S^{\frac{1}{2}} \qquad (3)$$

If the value of Q is taken as the total runoff at the culvert, then V is the velocity at that point.

*Civil Engineer, St. Louis Sewer Dept., 5842 Julian Ave., St. Louis, Mo.

The mean velocity of the whole stream length is assumed to be two-thirds of the outlet velocity, or $V_m = \frac{2}{3}V$; and the time (in minutes) of flow from the upper end of the watercourse to the culvert will be

$$t = \frac{L}{60\,V_m} = \frac{3}{2}\frac{L}{60\,V} = \frac{L}{40\,V} \qquad (4)$$

From these four formulas the required culvert area may be determined. Eliminating r from (2) and (3) gives

$$Q = \frac{78.5\,V^4}{(50)^4\,S^2} \qquad (5)$$

Eliminating V from (4) and (5) gives

$$Q = \frac{78.5\,L^4}{(2000)^4\,t^4\,S^2} \qquad (6)$$

Eliminating t from (1) and (6) gives

$$(Q)^7 = \frac{(2000)^4\,(6)^8\,A^8\,S^3}{78.5\,L^4}$$

or

$$Q = 320\frac{A^2\,S^{\frac{3}{4}}}{L^{\frac{1}{2}}} \qquad (7)$$

or approximately

$$Q = 320\left(\frac{A^2}{L}\right)^{\frac{1}{2}}S^{\frac{3}{4}} \qquad (8)$$

This is the total runoff of the valley, or the amount of water to be carried through the culvert, in cubic feet per second.

If the culvert is laid on approximately the same grade as the stream, and the approach is well designed, it may be assumed that the velocity through the culvert is the same as that in the stream immediately above. Then if a is the area of culvert opening in square feet, $a\,V = Q$, or (from (5)

$$a\left(\frac{50^4\,S^2\,Q}{78.5}\right)^{\frac{1}{4}} = Q$$

and substituting Q from (7)

$$a = 4.5\left(\frac{A^2}{L}\right)^{\frac{2}{7}}\frac{1}{S^{\frac{3}{4}}}$$

or approximately

$$a = 4.5\left(\frac{A^2}{L}\right)^{\frac{3}{7}}\frac{1}{S^{\frac{3}{4}}} \qquad (9)$$

In actual practice, the values of L and S are as easily obtainable as that of the acreage A, either from contour maps or from actual traverse of the watershed, and these values add greatly to the flexibility of the formula.

For approximate work, values of S may be taken as 0.005, 0.01, 0.015, 0.02 and 0.04 (that is, 5, 10, 15, 20 and 50 feet per thousand), corresponding to slopes from very flat to steep.

Then for

$$S = 0.005 \quad a = 13.0\left(\frac{A^2}{L}\right)^{\frac{3}{7}}$$

$$0.01 \quad a = 11.3\left(\frac{A^2}{L}\right)^{\frac{3}{7}}$$

$$0.015 \quad a = 10.4\left(\frac{A^2}{L}\right)^{\frac{3}{7}}$$

$$0.02 \quad a = 9.8\left(\frac{A^2}{L}\right)^{\frac{3}{7}}$$

$$0.04 \quad a = 8.6\left(\frac{A^2}{L}\right)^{\frac{3}{7}}$$

Also L may be reduced to a function of A by assuming the shape of the valley, or ratio of length to breadth: thus if the area is approximately square, $\frac{L^2}{43{,}560} = A$, or $L = 208\,A^{\frac{1}{2}}$; for $S = 0.005$, a becomes $1.3\,A^{\frac{6}{14}}$ or approximately $a = 1.3\,A^{\frac{3}{7}}$; for length twice the width of the valley $a = 1.14\,A^{\frac{3}{7}}$.

In general, the formula may be written $a = C\,A^{\frac{3}{7}}$. Values of C for various slopes and various ratios of length to width of the drainage area are tabulated below:

VALUES OF C IN FORMULA $A = C\,A^{\frac{3}{7}}$

Slope S	0.001	0.005	0.01	0.015	0.02	0.04
L = w	1.76	1.32	1.15	1.06	1.00	0.87
L = 2w	1.52	1.14	0.99	0.91	0.86	0.75
L = 3w	1.39	1.04	0.91	0.83	0.79	0.69
L = 5w	1.24	0.93	0.81	0.75	0.71	0.62
L = 10w	1.06	0.80	0.70	0.64	0.61	0.53

In the preceding, the cross-section of the high-water channel was assumed to be a semicircle. The error in this assumption will not be great where the slope of the stream is 1% or more, as such watercourses usually have compact sections and are not subject to overflow to any great extent. For flat grades, however, the cross-section at high water usually consists of a small channel flanked by wide overflow areas in which the velocities are low, and the mean velocity may possibly be as much as 25% less than that given by equation (2). Assuming such condition, for example a flat triangular channel having a width ten times the depth, it is found that the discharge a would be

$$Q = 271\left(\frac{A^2}{L}\right)^{\frac{1}{2}}S^{\frac{1}{2}}$$

or about 16% less than that of the formula, while the required culvert area would be

$$a = 5.3\left(\frac{A^2}{L}\right)^{\frac{2}{7}}\left(\frac{L}{S}\right)^{\frac{1}{7}}$$

or 18% greater than the value of equation (9).

In general, when applying the formula to channels on very flat slopes and subject to overflow, the values of the constant C in the table should be increased 10% to 15%.

It should be noted also that the discussion assumes the velocity of the stream above the culvert to continue through the opening, and it is important that the shape of the culvert should approximate the cross-section of the stream and that well designed wing or approach walls be used in order to prevent disturbance to flow, or eddy action, as far as possible. Where this is not practicable, as in the case of shallow channels, the values in the table should be regarded as minimum, and the area of the opening increased, or else it must be permissible that the water level of the stream rise above the top of the culvert in order, in acquiring the head necessary, to overcome that lost in change of section.

Property Owners on a Public Highway cannot be compelled to pay for a pavement, if the pavement is notoriously unsatisfactory, according to a recent decision in an Oklahoma court. The cases decided were those of three citizens of the city of Bartlesville, who succeeded in obtaining a permanent injunction against the city to prevent the collection of assessments for an asphalt pavement in Johnstone Ave. It is claimed that the surface of the pavement came off a few weeks after it was laid, and the taxpayers refused to meet further assessments. The city's motion for a new trial was overruled, and the injunction was sustained.

An Installation of Freight-Handling Machinery for Increasing Dock Capacity*

An overhead freight-handling system has been recently installed at one of the docks and storehouses of the New York Dock Co., in Brooklyn.† Here is a six-story brick structure 211x68 ft. which is used solely for sorting and storing export and import cargos. The freight is what comprises the usual miscellaneous ocean burden, with every kind and size of box, barrel, keg, crate, bale, flask, sack, and even metal bars and sheets. It has to be carried directly to and from lighters, wagons, trucks and railway cars, as well as into and out of storage buildings.

The equipment noted consists of a single-runway bridge on the adjacent wharf extending to the warehouse; two I-beam (15-in.) tracks through this warehouse; a double-runway bridge over railway tracks to a freight house, and two traveling hoists. The wharf bridge (Fig. 1) extends from the warehouse door to the dock face, 76 ft., spanning two railway tracks and the wharf. At the end is a rising apron, with I-beam track, which can be lowered after a lighter has docked so that the trolley hoists may be run out over the deck for loads.

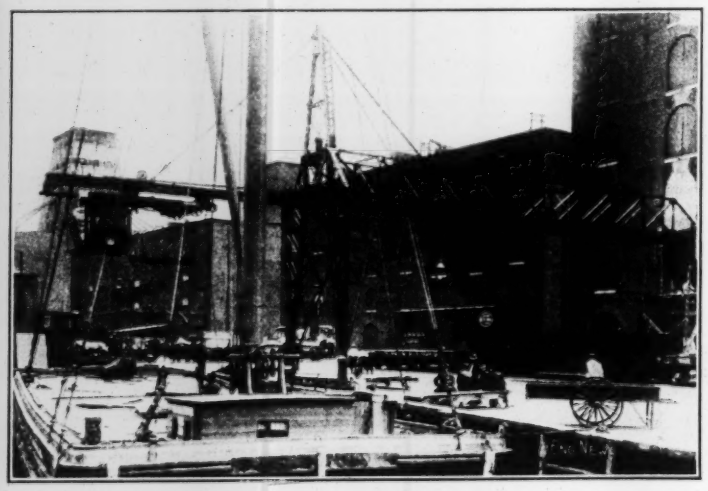


FIG. 1. WHARF BRIDGE WITH RISING APRON FOR UNLOADING LIGHTERS; NEW YORK DOCK CO.

The track from the wharf bridge, runs into the second story of the warehouse and, just inside, branches into two tracks with a switch worked by hand chains from the floor. These two suspended tracks run to the rear of the building, turn to the right past an elevator and leave the building, passing on a structural bridge 103 ft. long, over a railway yard (Fig. 2) to a freight house. This bridge is supported on two shear legs and the freight-house roof.

The trolley hoists have a capacity of 2¼ tons. Each has two four-wheel trucks swiveled to take curves of 15-ft. radius. The wheels travel on the lower flange of the I-beam, and two wheels of each truck are driven through spur gears by the travel motors. The hoisting motor is carried on the main trolley frame and geared to two drums. There is a two-part hoisting cable for each drum and these carry an intermediate frame through sheaves as shown in the accompanying figure. The limiting height of hoist is 30 ft. The hoisting speed is 50 ft. per min. loaded, or 120 ft. empty. The travel speed varies from 450 ft. per min. loaded to 550 empty. Mechanical and solenoid brakes control the hoist loads. Direct current at 220 volts is obtained through spring and wheel collectors running on wires strung along the tracks. Current is purchased from the local electricity-supply company.

For gathering miscellaneous freight, there are 12 two-ton trucks (Fig. 2) with two 10-in. ball-bearing wheels at one end, and two two-wheel swivel casters on the other end. At each end is a steel frame to hold in the load, with a hook plate for hoisting. Each truck is 8½x3½ ft. over all, and can easily be pushed around when fully loaded. For carrying bars and plates the intermediate hoisting frame carries a center hook.

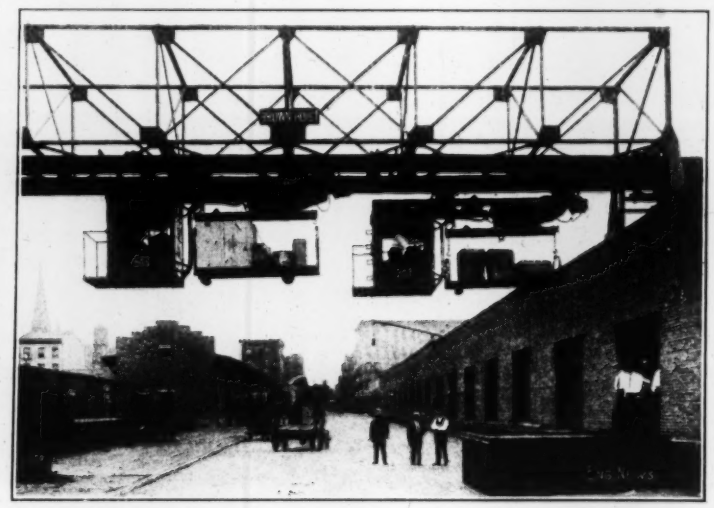


FIG. 2. TWO-TRACK BRIDGE FOR FREIGHT TRANSFER; NEW YORK DOCK CO.

Ocean steamers dock at the various piers and unload to piers and lighters. On the piers, this freight is distributed by hand trucks. The loaded lighters are towed under this equipment (as in Fig. 1) and the freight carried to the freight house, if for land transfer, or to the warehouse, if for reshipment by water. Lighters and vessels are also loaded by a reverse process. In the warehouse, the trolleys work in connection with an elevator and a chute for distributing and assembling freight. When a trolley leaves a truck load, it picks up another truck without waiting for unloading and loading.

While this plant is not yet running to full capacity, it has already replaced 12 laborers. There are claimed (1) a greater promptness in shipments, with decrease in demurrage costs; (2) elimination of wagon congestion about this dock, and (3) 50% reduction in cost of handling freight. The equipment shown was built by the Brown Hoisting Machinery Co., of Cleveland, Ohio, under the direction of F. R. Lackey, general manager of the New York Dock Co., and J. W. Galbreath, consulting engineer.

*From information furnished by the Brown Hoisting Machinery Co., Cleveland, Ohio.

†This company has docks along about 2¼ miles of the Brooklyn shore of New York Bay with some 300 acres of land for warehouses and railway tracks. The company has its own tracks along the water front and to the warehouses, using dinkey locomotives for handling the cars. The only connection with the various transportation lines is by car lighters and a ferry slip. Large steamers may dock at 27 piers on which the railroad tracks do not run, so that the freight has to be handled by lighters or wagons.

EDITORIALS

Do Civil Engineering Graduates Practice Engineering?

In a recent address Prof. Chas. L. Crandall, of the College of Civil Enginering of Cornell University, stated that a canvass of the 1303 living graduates of that college showed the following classifications:

Chief engineers	40
Consulting engineers	64
Practicing engineers	953
Contractors	34
Teachers	69
Presidents of companies	27
Miscellaneous	116

In this classification the "presidents of companies" includes the President of the Republic of Cuba and the "miscellaneous" group includes business men, farmers, lawyers, ministers, doctors and dentists.

It will thus be seen that 1057, or 81% of the entire number of living graduates, are engaged in the direct practice of the profession for which they were educated; and if the contractors and the teachers are included, the total rises to 1160, or 89% of the whole.

The percentages are certainly much larger than current discussions of the status of the profession would lead one to infer. These figures would indicate that, for the graduates of one college at least, the attractions of the engineering profession are sufficient to engage the services of by far the greater number of those who were led by youthful ambition to a four years' study of its elements.

It is to be assumed that almost all of the men who study civil engineering follow it a few years after graduation, so that the percentage of outside businesses or professions should be greater among the older men. While the number of graduates in the College of Civil Engineering of Cornell has increased materially each year for the past ten or fifteen years, as it has in most of the colleges, still the number of graduates who left the University ten years or more ago is quite large, and the record noted above would be more interesting if the same classification could be given for the older graduates only.

More Offers of Commissions to Engineers

In every professional code of ethics written or unwritten, one rule invariably found is that a professional man holds a trust relation toward his client and that this trust relation is vitiated by the acceptance of any compensation, direct or indirect, coming from any person other than the client, upon work in which the client's interests are involved.

It seems strange that this rule should not be universally understood; but at a recent meeting of the Institute of Consulting Engineers a member of the Institute reported the receipt of offers from a patent attorney to give a commission on such fees as might be received from any client which the engineer might recommend to him.

We are also in receipt of a letter from a well known architect and consulting engineer, inclosing a copy of a card sent out by a reputable dealer in a certain line of builders' supplies. The card, which is intended to be signed and returned by the architect, contains the following over the blank for signature:

> In cases where a sale of your ——— are a direct result of our specifying them and such sale does not conflict with your agents, and where our code of ethics will permit us to accept it, we leave to your discretion and liberality any commission you may allow us on such sales.

It is obvious that the architect who should be foolish enough to sign such a card, would at once place his reputation at the mercy of the concern holding the card.

We can but believe that the use of such methods for obtaining business is generally due to the advent into the business department of a concern of some green hand with more shrewdness than principle or experience. It ought to be obvious that the circulation by any business concern of such offers among architects or engineers would be sufficient to absolutely prevent any reputable architect or engineer from using the concern's goods. Such a concern would at once and very properly be placed upon a black list, since to specify its products would lay him open to the charge of having accepted its offer of a commission.

Is Man Responsible for Floods?

In hundreds of newspaper editorials and doubtless as many more pulpit discourses, during the past month, it has been learnedly explained that the recent great floods were caused by changes which have been brought about by the hand of man. It is repeated everywhere that such great floods are a direct result of the wanton destruction of the forests, the cultivation of the soil, the drainage of swamps, the paving of streets and roads. All these things, it is said, cause the water which falls from the skies to run quickly off into the streams instead of soaking into the ground.

Such ideas are so widespread and one hears them so often expressed, even by engineers, that it seems worth while to inquire what scientific foundation this theory has.

Let us say at once that we shall not at this time take up again the much discussed subject as to the general effect of forests on the runoff from drainage areas. We wish to refer only to the effect of a forest cover or a forest mulch upon the rate of runoff from drainage areas subjected to extraordinary rainfall. Here, it seems to us, the case is so clear that engineers of all shades of opinion can come to unanimous agreement. It may be admitted that under favorable conditions an inch or even two inches of rainfall may be absorbed like a sponge by the deep mulch of decayed vegetable matter covering the floor of a primeval forest. After this mulch is once saturated, however, further soaking in of additional rain-

fall is extremely slow. If then the rains still continue, the additional water flows off from the flooded ground surface very rapidly.

Take the conditions which existed in the territory of heaviest rainfall in northern Ohio during the last week in March. Nearly a foot in depth of water fell from the skies within a period of four days. It is obvious that such conditions mean a rapid rate of runoff and enormous discharge even in a forest where the ground is covered deep with leaf mold.

And this is not mere theory but is what actually happens and has been many times observed. We doubt not that every engineer who has had occasion to observe stream flow and runoff in different parts of the country, has many times seen brooks and rivers flowing from densely forested regions which were swollen to great flood volume by heavy rainfall or melting snow.

Official flood records tell the same story. Many of our readers noticed, without doubt, that the recent great flood in the Hudson River at Troy was after all less in volume and in flood height than the flood recorded in the same river in February, 1857. But nearly all the waters of the Hudson River above its junction with the Mohawk come from the Adirondack region, which in 1857 had hardly been touched by lumbermen. Moreover, as those who know the Adirondack plateau are well aware, it contains an extraordinary number of natural reservoirs in the form of lakes and ponds, and great areas of swamp and comparatively level land. If the theorists who ascribe the present-day floods to the removal of the forest and the drainage of the swamps were correct, then the drainage area of the Hudson in 1857 could not possibly have produced such a record-breaking flood.

It will doubtless be admitted that if the removal of the forest and its mulch covering the soil has had no part in producing great floods, then no changes brought about through the cultivation of the soil, the building of roads or cities, or the drainage of swamps has had any more effect.

It is of interest, however, to refer here to the flood records quoted by Col. Townsend in our issue of Apr. 17, where he showed that the highest water ever recorded in the Mississippi River at St. Louis was in 1844 and the next highest in 1785. At the later of these dates as well as the earlier, the entire territory drained by the upper Mississippi and Missouri was practically untouched by man and in a state of Nature. These records of early great floods in the Mississippi are sufficient comment on those who hold the common theory that the breaking up of the prairie sod has increased the rate of rainfall or the rate of runoff.

Doubtless the fact that a great flood occurred in the lower Mississippi last year and has been followed by one of almost equal magnitude this year will form a convincing argument in the minds of some millions of people that floods are increasing in frequency. The engineer, however, who is at all familiar with records of weather, rainfall and stream flow, covering an extended period of years, knows that cycles of dry years and of wet years are apt to follow one another. Apparently the cycle of dry years which caused such great distress and damage by drought and failure of city water supplies all through the Eastern states during 1910 and 1911 has come to an end, and we are entering upon a cycle of wet years of unknown duration. This does not at all mean, as many fancy, that weather conditions are changing. There is little, if any, evidence to show that anywhere on earth any noticeable climatic change has occurred important enough to be noticeable within recent historic times.

We know of no reason, therefore, for believing that the floods which have caused such devastation during the present Spring are anything different from what has occurred before and may occur again; and they are no more likely to recur next year or the year after than they were twenty-five years or fifty years or a century ago.

The only qualification to be made to this statement is the alterations which have been introduced by man upon the river channels themselves, which have at certain points reduced their capacity to carry off high floods. These changes, the encroachment upon the river channel and its obstruction by bridge piers, dams, etc., have already been discussed fully in our columns in connection with the recent floods.

A word may be said, however, concerning the alleged injury to the channels of streams due to their being filled up by sediment, etc., carried into them. There are undoubtedly certain locations such as the American River in California, whose channel has been filled up by the débris from mining operations, where great injury has been done to stream channels through man's agency. There are also, probably, localities where erosion of the soil due to cultivation has carried a material amount of sediment into the streams, more than would have been discharged there under natural conditions.

When, however, we contrast the quantities of such sediment which can be traced to man's agency with the huge quantities which the river has brought down in its natural condition, the part that man has played is seen to be puny indeed. The Missouri River, for example, was known as the "Big Muddy" from the vast amount of sediment it carried long before any farmers were tilling the land draining into it.

Furthermore, as every engineer who has studied elementary geology is aware, erosion of lands by streams and rivers is a process which is all the time going on. The alluvial bottom lands along the course of every stream, great and small, are in fact a deposit which is in itself conclusive proof of the vast amount of sediment, gravel, sand, etc., brought down by the stream during long centuries past. Except for such local cases as the injury of streams by mine discharge, therefore, there is little reason to suppose that the agency of man has played any appreciable part in filling up the beds of rivers with deposits and lessening their flood capacity.

It seems to us that these scientific facts should be understood and appreciated by engineers at this time when so much pseudo-science is afloat and when the public particularly needs correct information on matters of this sort. The danger is that the public, which has hitherto been blind to the need of any engineering responsibility for river regulation, will now swing to the opposite extreme and expect the engineer to accomplish impossibilities.

We have already emphasized in these columns the need of the establishment of scientific river regulation in this country under proper government direction. The present year's floods serve to awaken the public to an appreciation of this need, but it is well that the public should understand at least the essentials of what can be and what cannot be accomplished.

The Meaning of the Los Angeles Bond Election.

The defeat of bond issues totalling $11,000,000 for the completion of work accessory to the Los Angeles Aqueduct at an election held on Apr. 15 should not be considered as in any sense a condemnation of that great project, on which the city has already expended or pledged itself to expend some $28,000,000. Instead, the defeat should at least raise the question as to the wisdom of the plans proposed for utilizing the surplus water of the aqueduct and also for utilizing the power which it is proposed to develop by the water drop at the lower end of the aqueduct.

Taking up first the utilization of the surplus waters, those interested in the details of two alternative plans which have been considered in the past may refer to a lengthy article on this subject published in our issue of Mar. 13. Suffice it to say here that the people did not vote on the very ingenious and sensible plan worked out some time ago by William Mulholland, chief engineer of the Los Angeles Aqueduct, and further developed and heartily approved by a commission of engineers, which reported upon the subject soon afterwards (See ENGINEERING NEWS, Dec. 29, 1910, and Oct. 26, 1912). Mr. Mulholland proposed to utilize the surplus waters of the aqueduct in areas near the city now devoted or susceptible of being devoted to intensive agriculture by means of irrigation. His proposition involved the bearing of the expense of a distribution system, or at least a large part of such a system, by the land owners. The Mulholland plan was founded on the fact that substantially the same amount of water is required in southern California for use on land devoted either to irrigation or to urban purposes. Mr. Mulholland, as explained in the article of Mar. 13, already mentioned, would have supplied this water to purchasers substantially at cost with the understanding that the area so supplied would eventually come into the city and that in the course of time the water-supply would change from that of an irrigation system to that of a regular city water-works system. The transition would be gradual and without any shock. Subsequently, there was substituted for this plan by a member of the board having supervision over the construction of the Los Angeles Aqueduct a plan of a far different sort. This plan involved carrying the water at city expense for considerable distances and there supplying it at its highest market value to irrigated lands, or lands to be put under irrigation, which in the nature of things could not be expected ever to be brought within the city. When years hence the city needed this supply for its own purposes it would have to cut off the water from these irrigated lands and leave their owners to shift for a water-supply as best they could. It was this latter plan, instead of the Mulholland plan, which was voted down by a very heavy majority on Apr. 15. The plan involved an expenditure of $4,500,000 for two different pipe-line systems.

Of course no one knows what the popular vote would have been had there been a choice between the so called Graham plan, just outlined, and the original Mulholland plan. There seems reason to believe, however, that the Mulholland plan would have been indorsed, particularly since, as we understand the case, it would have involved a comparatively small outlay.

The people of Los Angeles did approve, by a very hearty vote, a proposition to issue $1,500,000 bonds for bringing from the end of the aqueduct to the city a sufficient amount of water to supplement the present sources of supply for a number of years. This, however, will take only one-tenth of the total supply made available by the aqueduct. In other words, it will dispose of 2000 miner's inches (1 miner's inch in southern California equals 1.2 cu.ft. per min.) and will leave 18,000 miner's inches for which no use can be provided. (The aqueduct capacity is some 258,000,000 gal.)

This is far from being all. It is stated that unless some means is provided for utilizing the remaining 90% of the water there will be no power to utilize and thus the power plant now under construction at the end of the aqueduct will be useless. An Eastener might think that the surplus water might be wasted after dropping through the power plant, but besides the fact that water in southern California is too valuable to waste, if it was thus discharged it would be liable to appropriation by public or private users below.

The whole aqueduct scheme since its early stages has contemplated the development of a large amount of power, which would be of great aid to the city in taking care of the capital expenditure for the water-supply developed under such conditions as to make it almost necessary to build an aqueduct now large enough to supply the city for many years to come.

It was for the reasons just outlined that there was inserted among the proposed bond issues voted on at the last election one for an issue of $6,500,000 for completing the power development now underway and for conveying that power to the city and distributing it there. This proposition got an absolute majority of almost 10,000 out of a total vote of a little over 51,000, but as a two-thirds majority was necessary the proposition was lost. (For the vote on each proposed bond issue, see table on p. 931.)

So close a vote as this where two-thirds majority is required, combined with the large actual majority given, cannot be accounted as a condemnation of either municipal ownership in general, or of this particular municipal ownership proposition; especially not when some local factors are taken into account. Chief of these, it appears, was the intense opposition of the local light and power companies, which have fought the whole aqueduct scheme, and particularly power development, since its inception but heretofore have never been victorious.

It should be noted that an economic principle was involved here, but whether or not it was really taken into account by the voters, or at least how fully it was taken into account, we cannot say. The proposed bond issue contemplated, as we understand it, a duplication of the existing system for distributing electric current for light and power within Los Angeles. All disinterested persons whose economic reasoning is sound know that such duplications are to be avoided wherever possible. The local light and power companies made some sort of offer to make unnecessary this duplication, by buying power from the city, or, we understand, by leasing their distribution system to the city. Circular letters, it appears, were sent out by the local light and power companies to their consumers, urging them as taxpayers to vote against the proposed power distribution bonds on the ground of heavy and unnecessary increased taxation. These letters urged

that the companies were willing to buy power from the city at a price which would materially reduce the taxes and that if the city distributed the power itself it would have to materially increase the tax rate, so that putting the two together they claimed a difference of some 50 or 60c. on the tax rate in favor of having the city lease the aqueduct power to the company instead of distributing the power at municipal expense.

It is claimed by those who were ardently in favor of full municipal ownership of the electric light and power systems that the companies would not, in the proposed alternative of leasing the company systems to the city, insert an option providing for municipal purchase. It looks from this as though, had the companies been willing to make more concessions or had they in common with other public-utility corporations in California not been so drastic in the past, an altogether different outcome of the election might have resulted. Anyway, as we have already intimated, this vote on the aqueduct power distribution bonds cannot be interpreted either as a condemnation of the aqueduct scheme or of municipal ownership. Now that the election is over it seems to be quite possible for the private and public interest to get together and effect a settlement of the controversy which would be fair to all concerned and a material economic gain over the duplication of distribution systems.

Another phase of the subject which may be mentioned in passing is that although the State of California passed a fairly strong public-utilities commission law a year or two ago, it left the rate regulation of local light and other public-utility companies to the city, in accordance with a long standing constitutional provision to that general effect. This has always been a bone of contention between the cities and various public-service companies, especially as rates are or may be established yearly. If the regulation of municipal public-service rates in California were in the hands of a state commission, such a situation as now exists in Los Angeles might be very much ameliorated, since the people would be in a much stronger position when able to choose between municipal ownership on the one hand and reasonable rate regulation by an outside state commission having experienced experts at its command.

Still another bond issue which was voted down, and which may, perhaps, be interpreted as disapproval of just that kind of municipal ownership, was for $1,000,000 to build a municipal railway from the business section of the city to and around the new harbor being developed by Los Angeles in the old settlement known as San Pedro, now a part of the city. The advocates of the railway claimed that municipal ownership of such a railway line is an absolute necessity if the city is to reap to the full the advantages of the harbor developments which are being carried out. Evidently, the large majority of the voters of Los Angeles thought differently. Certainly, in the light of American practice, such an expedient is far more doubtful than municipal ownership of some other public utilities.

Why the voters threw down the city hall ($1,000,000) the civic center ($600,000) propositions we will not undertake to say, unless it was that the proposed total bond issue of $17,600,000 at a time when capital charges on outstanding bonds already make up a large part of local taxes was altogether more than the people cared to indorse. The city seems to be in need of a modern and capacious city hall, but perhaps it needs other things more just at present. The proposed purchase of a commanding site for a civic center appears to have been an issue almost forced to a vote by its enthusiastic supporters—apparently against the judgment of a considerable portion of the city fathers.

The Los Angeles bond election, as well as the charter election some three weeks earlier at which 17 charter amendments and one initiative ordinance were voted upon, both go to show that in western cities at least the people can vote discriminatingly on even a large number of propositions at one time. At both elections nearly all the votes were decisive either one way or the other; even the $6,500,000 bond issue for adequate power developmnt had a very actual though not a legal majority, as we have already stated.

It is interesting to note that in the charter election the vote went almost wholly as advised by a number of civic organizations which acted together on the subject, as well as by two newspapers of the city, while in the bond election most of the adverse decisions were contrary to the advice of the same newspapers and also to a number of civic organizations. Curiously enough, too, the public-service corporations were represented as being dead against a number of the charter amendments, which went through with good majorities, just as they were against, with success, most or all of the proposed bond issues voted upon three weeks later.

The net result of the Los Angeles situation, while perplexing in some respects, is on the whole hopeful. People voted strongly in favor of carrying on the harbor improvement and of bringing water needed for city purposes to the city at once. They defeated the surplus water distribution and the power development distribution bonds, but, as we have pointed out, they were not permitted to vote on alternative propositions which the majority of the people may perhaps have favored and which would not in any way have sacrificed the principle of municipal ownership—except to a possible minor extent in connection with the full operation of the electric light and power distribution system.

The votes were scarcely counted before the leading city officials were at work on plans for meeting the situation developed by the election. In fact, the possible failure of the bond issues had been discounted and formulation of plans had been begun long before the election.

We have every reason to believe that the magnificent aqueduct scheme conceived by Wm. Mulholland and others and so successfully carried out by Mr. Mulholland Mr. Lippincott and scores of other engineers, assisted by Mr. Scattergood as to power utilization, will come to a full and satisfactory fruition without any material loss of time. The water-supply, irrigation and power development associated with the aqueduct taken together constitute one of the most remarkable pieces of municipal enterprise ever yet undertaken in any part of the world. We are sure that the people of Los Angeles will not let any part of these grand schemes fail. We trust that in their zeal for municipal ownership they will not go so far as to enter into any such economic waste as the duplication of power distribution systems, unless the local companies are so uncompromising as to make something of the kind absolutely necessary in the protection of the interests of Los Angeles.

LETTERS TO THE EDITOR

The Study of Foreign Languages for Engineers

Sir—It is a significant fact that all the discussions in ENGINEERING NEWS about the study of foreign languages for engineers, mention not one word about the value of general literature.

Is general culture not worth even mentioning by the present American engineer? It is superfluous to argue the necessity for a cultured person to read and know literature. Where is there a richer literature than the German or French? Think of Goethe, Schiller, Heine, Lessing, Zuderman and Hauptmann, or Balzac, Victor Hugo, Maupassant, Flaubert, Anatole France and Maeterlinck. For these few alone, it is worth while to be able to read them in their own tongue and not in some translation which can reflect but little of the richness of their minds.

While in Europe, I was told that some German engineers studied English for the sole purpose of reading Shakespeare, while a French engineer had studied German to read, in the original, Goethe and Heine; another German engineer studied the Russian language to be able to read Turgenieff's and Tolstoi's books.

From the point of view of the American engineer, who has only fifty or sixty years to live and who in that short time must cram in a few dozen engineering books and build a few dozen railroads, the act of the last named German would be a sign of a high order of insanity. From the European point of view it is the sign of a high degree of culture.

Can it be a fact that the American engineer has not yet reached the standard level of culture of the twentieth century?

S. RESWICK.

N. Y. State Barge Canal,
Fulton, N. Y., Apr. 21, 1913.

A Reinforced-Concrete Dam That Has Safely Passed Its Second Flood

Sir—A reinforced-concrete dam of the Ransome type was constructed during 1912 in the Gorge of the Cuyahoga River, by the Northern Ohio Power Co. During the recent unprecedented floods in Ohio, this dam was subjected to an exceptionally unusual condition.

The dam is about 450 ft. long at the crest, and the spillway at about the center of the dam is only 119 ft. long, the crest being 5 ft. above the spillway.

The highest rate of flow in this stream which had been recorded prior to March, 1913, amounted to 2920 sec.-ft. and this spillway was designed to carry a maximum of 4400 sec.-ft. During the recent flood, however, the maximum flow rose to about 14,500 sec.-ft., not only completely filling the spillway but rising to a height of some 3 ft. above the crest.

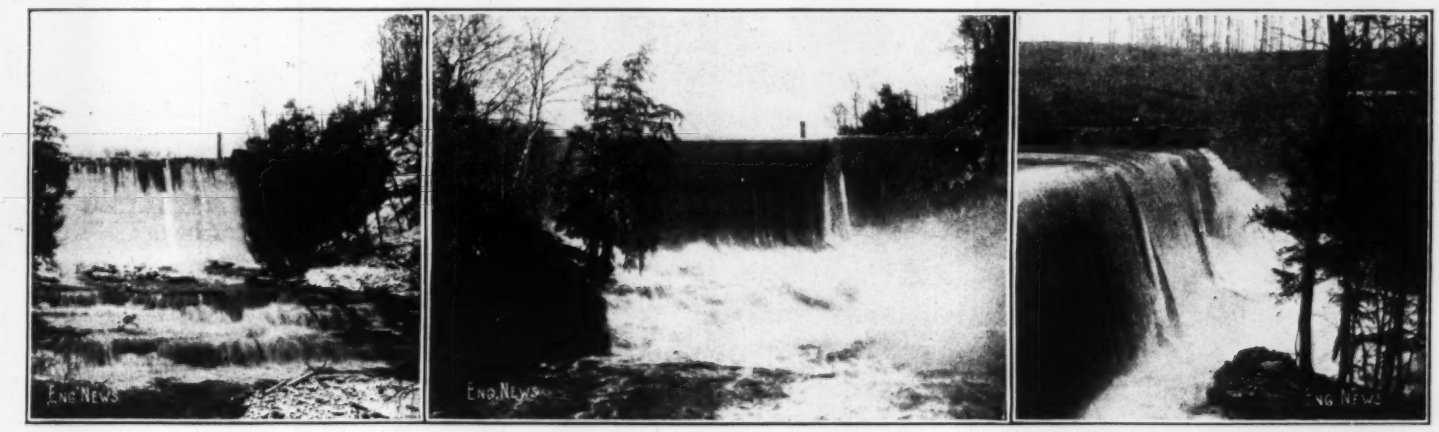


FIG. 1. AT NORMAL FLOW

FIG. 2. FLOOD FLOW, LOOKING UPSTREAM

FIG. 3. SAME FLOOD, LOOKING ACROSS STREAM

FIGS. 1 TO 3. VIEWS OF REINFORCED-CONCRETE DAM OF NORTHERN OHIO POWER CO., AKRON, OHIO, UNDER NORMAL AND RECENT FLOOD CONDITIONS

Fortunately, this dam was founded upon solid rock and securely tied into the rock at the sides of the gorge at both ends. Since the water has gone down the writer has made a personal examination of this dam and has been unable to find any sign that the slightest damage was caused by the flood. The stream bed is of solid rock or shale and was deepened 2 or 3 ft. for a mile or so below the dam by the scouring action of boulders which were moved by the water. Some boulders equivalent to a 6-ft. cube were moved several hundred feet.

This dam was also subjected to an unusually severe test during construction, as described in your issue of Nov. 14, 1912, p. 917.

The accompanying photographs show normal conditions and conditions during the height of the flood.

J. C. LATHROP,
Of the Northern Ohio Power Co.
Akron, Ohio, Apr. 10, 1913.

Repairs to the So. Halsted St. Lift Bridge over the Chicago River

Sir—Will you be good enough to let me know from whom I can obtain a clear, accurate and unbiased statement regarding the So. Halsted St. lift bridge, Chicago, from its inception up to the present date.

I have been informed by one party that the repairs to that bridge during a period of nine years came to $60,000, of which $8000 were spent in renewing the cables. From another source I have been informed that the original cables are still in use, and that the heavy cost of maintenance was due to substituting electric for steam power in connection with the hoisting apparatus.

F. C. GAMBLE,
Chief Engineer, Department of Railways, British Columbia.

Victoria, B. C., Feb. 26, 1913.

[We made inquiry as to the above from Mr. Hammond, Engineer of Bridges and Harbor, Department of Public Works, Chicago, and he gives the figures of cost of maintenance and repairs of this bridge for the period 1905-1912 (both inclusive) as follows:

1905	Steam operated	$4,628
1906	Steam operated	6,428
1907	Steam operated 10 months	15,461
1907	Electrically operated 2 months	
1908	Electrically operated	5,481
1909	Electrically operated	7,722
1910	Electrically operated	6,369
1911	Electrically operated	6,369
1912	Electrically operated	17,093
	Total	$69.551

Prior to 1907 the bridge was operated by steam, and the cost of coal for one year amounted to $2000; whereas with the present electric power the cost of current for one year amounts to but $600. It will be noted also that there was considerable expense in changing over the plant from steam to electricity in 1907, but the actual power cost for electricity was considerably less than for steam. The operating cables were renewed in 1912 and this will account for the high cost of maintenance for that year. Mr. Hammond states that this was the first renewal of the operating cables since the completion of the bridge. The counterweight cables, however, were renewed several years ago. When the operating cables were renewed it was necessary to renew the anchor bolts which were attached to the counterweight cables. These anchor bolts had rusted so badly that one or two bolts having an original diameter of approximately 2 in. had been reduced to nearly 1 in.

In regard to an accident which occurred to this bridge on June 8, 1911, the bridge tender's report was as follows:

> The bridge was being raised to allow a steamer and tug to pass, and when the span was about 20 ft. from the top, an eye-bolt holding the counterweight broke, allowing one tier of weights at the northeast corner to fall. The bridge began to come down, but was checked by the brakes when about half way down and was then slowly let down.

The damage done to the bridge was the loss of the row of counterweights and the eye-bolt.

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A Flood From Underground Waters at Bellevue, Ohio

Sir—We are inclosing herewith an article from the Athens, Ohio, *Messenger*, under date of Apr. 11, describing interesting conditions at Bellevue, Ohio.

For some weeks past this town of 6000 people has been flooded with waters coming largely from the overflow of an underground stream known as "Cold Creek," which is supposed to have its principal outlet at Castalia, some miles to the north.

Bellevue is unique in possessing perhaps the only system of vertical sewers to be found in the country. There is no surface drainage. There are no horizontal sewers, and the town depends entirely for drainage upon the artificial drilled holes and the natural sinkholes leading down into the caverns underneath the town.

W. J. SHERMAN.

The Nasby, Toledo, Ohio, Apr. 18, 1913.

[The article inclosed states that parts of Seneca, Sandusky, Erie and Huron counties, in Ohio, have no surface streams of consequence, the runoff being mostly through underground channels in the limestone. Bellevue is within this area and relies upon perforations to these channels for the removal of both sewage and storm water. The story continues:

> There have been failures in this plan on one or more occasions, and the late flood conditions in Ohio developed the most conspicuous failure in all the history of the place. As long as the sinkholes took the water and carried it to some outlet, all was well, but with the torrential rains of the past few weeks, the underground passages filled to overflowing, and instead of a drainage outlet your sinkhole became a spouting geyser. Today, when all rivers and creeks have sought their natural channels, many of the sinkholes of Bellevue and vicinity continue to pour out upon the earth a flood of water.
>
> But the flowing of the sinks is not the most peculiar part of the present phenomenon. One would suppose that the water flowing from the sinks would be flood water admitted to the underground passages at a higher level and discharged at a lower one. This supposition seems to be disproved, because the water flowing from the sinks in many instances is wholly different from the flood water, in that it is crystal clear and impregnated by mineral deposits resembling the water coming from the immense Blue Hole spring at Castalia, seven miles north of Bellevue, or the famous Green Spring at Greenspring, twelve miles to the west.
>
> Sinkholes in Bellevue, right in the midst of lakes of flood water are spouting aqua pura from unknown underground reservoirs. Unquestionably there exists an underground water channel under the section of the state referred to, but all attempts to locate its place of discharge have met with failure. Corks and cork dust and other material of buoyancy have been introduced in the sinks at Bellevue in an effort to locate the mouth of the underground river, but nary a sign of any of these telltales has been found either in the Blue Hole at Castalia or in Sandusky bay.
>
> Bellevue has had the worst flood in her history, although the water in but few places would measure over two or three feet deep. The only damage done has been the flooding of cellars and the low places in streets. In the country near-by many acres of land are submerged and will be until the water in the underground passages is lowered and the sinks that disgorged the water reverse themselves and carry it down below.
>
> This is perhaps the most peculiar flood situation in Ohio, and while no lives were endangered some considerable loss has been experienced. While other cities and towns are now relieved from flood conditions, Bellevue's flood still maintains and probably will continue for another week.

It is lucky for Bellevue that this is not a case of sewage regurgitation.—ED.]

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Stereophotographic Surveying

Sir—Otto Lemberger's history of stereophotographic surveying, in ENGINEERING NEWS of Mar. 27, is a very complete summary of the application of photography to surveying. The principles of the new process of stereophotogrammetry, as yet little known in America, are

clearly explained; its latest developments are described and its advantages well brought out.

After reading the article, the question which naturally arises is why, if photogrammetry offers so many advantages, is it not more extensively used? This is due to several causes. In the first place, photographic surveys require very efficient direction. Ordinary topographic surveys, whether executed by plane table, stadia, or otherwise, are largely a work of routine: in Europe, they are mostly executed by noncommissioned officers and privates of the engineering corps after a short and rudimentary training.

The surveyor knows that he has to collect certain data: his notebook or plans show him when these data have been secured. The photographic surveyor, on the other hand, has nothing before his eyes to show the progress of the work or the gaps that may exist in it. His undeveloped plates are his records: every time he exposes one, he must have present in his mind what it will give, what amount of information he can extract from it, what geometrical constructions he will apply, what further views are necessary and how they will combine.

Under no circumstances has a surveyor to display more skill and ability than when using the camera: he requires not only experience but a combination of the faculties which make an accomplished topographer. These acquirements are not the lot of every topographer and unless a man is well qualified, his attempts at photographic surveying cannot be successful.

The purely photographic part of the work affords other causes of failure. The views wanted, if they include distance, are the most difficult to obtain; they cannot be taken on ordinary plates and orthochromatic plates although suitable, present difficulties of their own. Views with great contrasts in the lights and shadows, or against the direction of the light are another source of trouble. Taking all this into consideration, what chance is there that a surveyor, at a first trial, generally with an extemporized apparatus, will be successful? A failure is almost inevitable and it is quite natural that he should discard the method as unreliable.

It must also be recognized that the photographic method has its limitations. For instance no combination of stations and views will enable the surveyor to plot a narrow road through tall woods. A flat country and a wooded country are equally unsuitable.

When, however, the conditions are favorable, results are obtained by photogrammetry which no other process can give. The latest photographic survey in Canada may be cited as an instance. It is a survey of the Mt. Robson region; it was made in 1911 by A. O. Wheeler, President of the Alpine Club of Canada, in the course of an expedition organized by the Club for the exploration of the Mt. Robson group of mountains and of the country adjacent to the Grand Trunk Pacific Ry. at the Yellowhead Pass. The expedition received a little assistance from the Grand Trunk Pacific Ry. Co. and from the provinces of Alberta and British Columbia. The instruments were loaned and the photographic plates furnished by my office The expedition started in July and came back in September: the survey, which was only one of its objects, covers about 50 miles in length with an average width of 20 miles. The map, which is published in the *Canadian Alpine Journal* for 1912, is a very fair one. Without photophy, nothing but a sketch of such an extensive tract could have been produced within the time available and with the limited resources at Mr. Wheeler's disposal.

Stereophotogrammetry has not yet been employed on Canadian surveys although it has engaged my attention for a long time. While Dr. Pulfrich was devising his well known instruments, I was working on the same problem. The solution which I proposed is described in a paper read in May, 1902, before the Royal Society of Canada: it is a Wheatstone stereoscope so arranged as to plot the plan automatically.

After the publication of Dr. Pulfrich's methods, I readily recognized that his solution was preferable to mine, and I did not continue the investigation further. Capt. Ritter von Orel's stereoautograph greatly facilitates the plotting of the plan and removes one of the objections most frequently urged against photogrammetry, viz., the length of time required for plotting.

The only difficulty that I can foresee is in finding suitable spots for camera stations. Let it be assumed for instance that from one place views have to be taken covering 180° in azimuth, the range of the plate being 60°. It will be necessary to find around the place three bases nearly horizontal, each in a definite azimuth and neither too long nor too short. It may not always be easy to find six spots suitable for camera stations when so many conditions have to be fulfilled; in a rough mountainous country it may be impossible.

Where stereophotogrammetry scores is for coast surveys: with a pair of cameras installed at the two ends of a ship, the survey of the coast is the acme of convenience, rapidity and simplicity. It is the ideal method for surveying uncharted coasts like those of Hudson Bay.

Speaking generally, it does not seem open to doubt that provided suitable camera stations can be had, the method will, when other conditions are favorable, prove the cheapest, quickest and often the most accurate of all topographical methods. It will also permit to make easily and conveniently surveys which otherwise are either very difficult or impossible, such as those of inaccessible spots or of objects in motion.

At the time the division of the waters of Niagara Falls was being considered by the International Waterways Commission, I was asked whether an accurate plan of the crest of the falls could be made: stereophotogrammetry alone could do that.

E. DEVILLE,
Surveyor General of Canada.
Dept. of the Interior, Ottawa, Ont., Apr. 7, 1913.

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ADDENDUM AND ERRATUM—In our article of Mar. 27, Dr. Deville's name was erroneously spelled Seville. A stereophotographic method of surveying was also devised independently by H. C. Fourcade, Forest Engineer, Capetown, South Africa, and was described by him in 1901 in the "Transactions" of the South African Philosophical Society His ideas originating independently of those of Dr. Pulfrich, are based on practically the same principles. A third independent experimenter was F. Vivian Thomson, Captain of the Royal Engineers of the British Army, who invented an instrument in 1908, which he called the "stereoplotter." The readings of the three movements of the stereocomparator were reduced to a single reading on a spirally graduated drum reading to yards, which gave the perpendicular distance of the observed point from the base line, which Thomson called the "projection of range." This distance was scaled off by an adjustable straight-edge and the point located in a manner similar to that employed in the stereoautograph of Capt. von Orel.—Ed.

The Cuyahoga River in the Flood of Mar. 25-26, 1913

By Edgar B. Thomas*

The area of the Cuyahoga River watershed is about 740 square miles. This area as a whole and as compared with other river watersheds of this country is of a "rolling" nature. Although both steep and flat slopes exist they are only in rather small amounts. Probably two-thirds of the surface is under a state of cultivation. This cultivation has a tendency to slightly increase the runoff, but its most costly affect upon Cleveland's inner harbor and the shipping interests and industries located in the Cuyahoga Valley and within the City of Cleveland is to deposit sediment in large quantities in the navigable channel. The dredging of this deposit is not only expensive, but its removal cannot be accomplished until after the opening of navigation on the Great Lakes, thereby causing river-bound vessels to lighter their cargo on the lake front or Ship Channel. This lightering involves delay and considerable additional expense to the shipper. In the case of extremely high water such as occurred last week, the deposit, reducing the cross-section of the channel, causes the water to rise higher, resulting in more damage.

When the rain began about 11 a.m. on the 23d, the frost was entirely out of the ground, but there had not been a sufficient rainfall to compact the soil. This condition had the effect of increasing the erosion and resulting in greater deposits in the river channel. Soundings taken since the flood indicate that the amount of maintenance dredging required this year will exceed 300,000 cu.yd., which is approximately twice the yardage removed in 1912.

The Cuyahoga River

The river from its source about 5 mi. north of Burton to its outlet at Lake Erie near Cleveland is about 90 mi. in length and has a total fall of about 700 ft. The upper 40 mi. of this stream has an average grade of about 5½ ft. per mi., while the fall at and near Cuyahoga Falls is about 200 ft. The 25 mi. of channel above the upstream limits of navigation in Cleveland has an average fall of about 3½ ft. per mi. The remaining 5½ mi. of navigable portion of the channel is dredged to a depth of 22 ft. and maintains practically lake level, except during high-water periods. The upstream 1½ mi. of the navigable channel, or that portion above the Erie Ry. bridge (from *C* to *D* in sketch map herewith) has a width

Fig. 1. Stern of Steamer "Wm. Henry Mack"

[Center pier of West 3rd St. Bridge No. 1 and portion of wrecked superstructure. Probably 90% of the wreck is under water.]

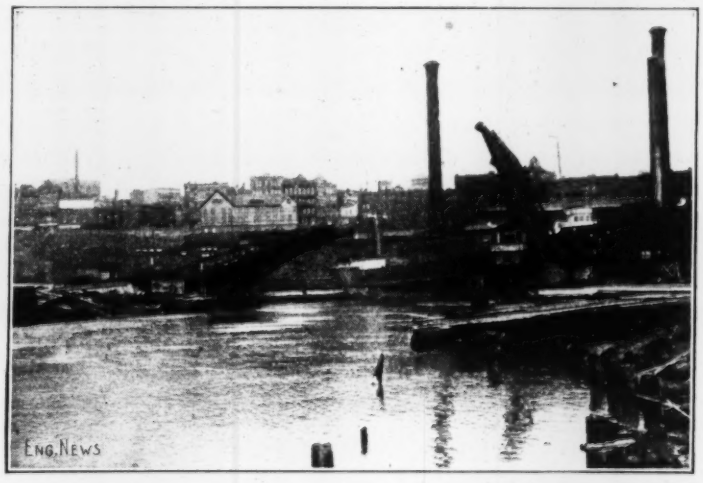


Fig. 2. West 3rd St. Bridge No. 2, Showing Position of Bridge When Motors Were Flooded

[The clear channel opening is about 110 ft., but, owing to the sharp bends immediately downstream, large vessels cannot pass through the bridge in its present position.]

Fig. 3. Lumber Boat "C. C. Barnes" on Wrecked Dock near Cincinnati Slip. About 5 Ft. Out of Water at Bow

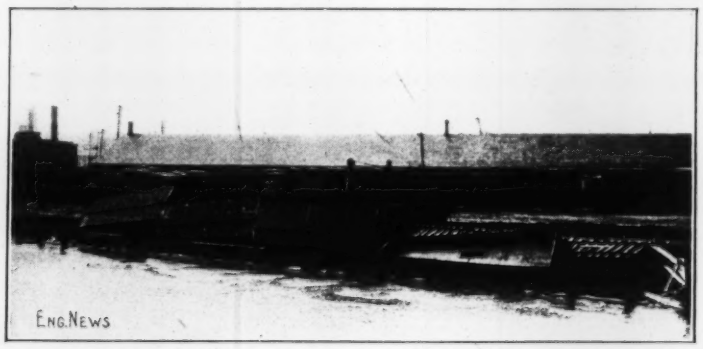


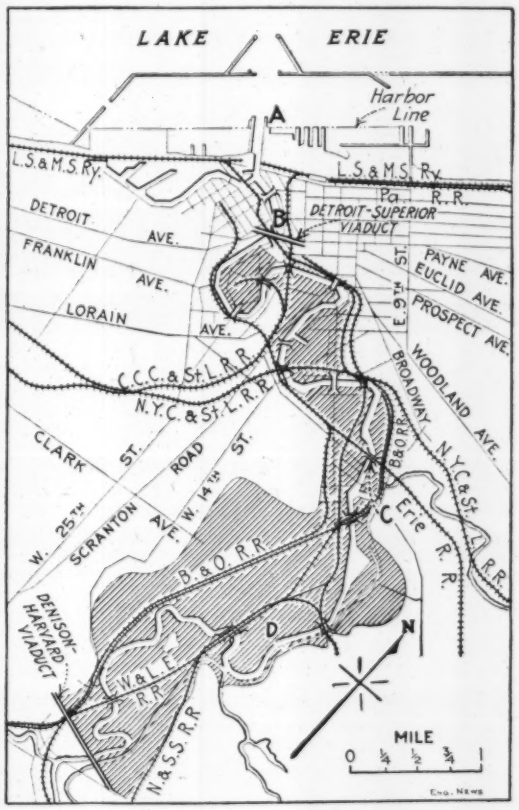
Fig. 4. View Showing Erie Ry. Co.'s Scranton Road Dock and Switch Tracks

[Long building is Scranton Rd. freight house. High-water mark is about 1 ft. above floor of cars standing on high track.]

Views along the Cuyahoga River in Cleveland, Ohio, after the Flood

*Asst. Engr. in charge of River & Harbor Department in the Engineering Division of the Department of Public Service, Cleveland, Ohio.

of 200 ft. and a depth from the dock level of about 31 ft., and is sufficiently straight for the navigation of the largest lake freight vessels. The bends are but few in number and offer but slight resistance to flow. The minimum width at bridges is about 140 ft. The ¾ mi. of channel from the Government pier heads in the lake to the Superior Viaduct (from *A* to *B*) has an average width of 280 ft., and the channel has a depth from the top of the docks of about 30 ft. At the Lake Shore & Michigan Southern Ry. bridge (the bridge nearest the lake) the channel is contracted to 130 ft. The remaining navigable portion of the channel, i.e., between the Superior Viaduct and the Erie Ry. bridge (from *B* to *C*) has an average width of 145 ft., a depth of 30 ft. from the top of docks, and a minimum width at bridges of about 110 ft. It is this portion of the river that caused



MAP OF CUYAHOGA RIVER IN CLEVELAND
(Hatching shows area flooded Mar. 25-26, 1913.)

practically all of the damage in Cleveland during the flood of Mar. 25-26.

CHANNEL CHOKED BY BENDS AND BRIDGES

The result of the flood was largely due to the existance of 12 sharp curves or bends having radii (to the center of the channel) and total deflections (exterior angles) as indicated in the following table:

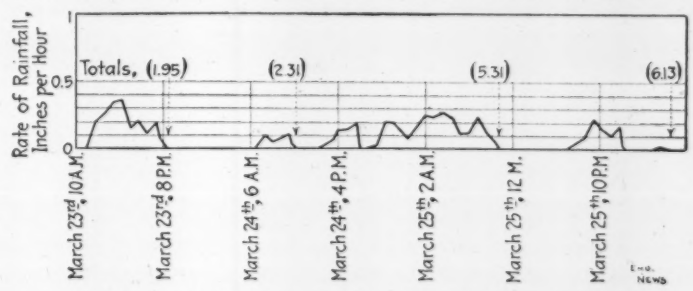
Location of bend	Radius ft.	Deflection Deg.	Min.
Dry Dock St.	372	108	
Mahoning Ave.	305	51	45
Walworth Run	520	46	
Cincinnati Slip	1250	21	15
West 6th St.	1110	39	45
Collision Bend	350	147	
Big Four Ry. Passenger Bridge	665	27	
B. & O. Freight Station	540	76	45
Girard St.	530	45	30
Columbus Road	405	92	05
Irishtown	772	81	30
Superior Viaduct	295	81	
Total		817	35

Between the Dry Dock St. bend and the bend at Superior Ave., the channel is contracted and obstructed in varying degrees by 13 bridges which cross the channel, five of which have center piers. From the above table it is apparent that the channel makes total deflections, in a distance of 2.85 mi., of considerably more than two complete circles, and the radii in most cases are extremely short. And, unfortunately, in four cases the bridges are located at or near bends.

After considering the number and character of the bends in the channel, the contraction at bridges and the obstruction caused by the center piers, it is evident that a mathematical computation to determine the flow in this channel would not only be difficult, but the result would be very unsatisfactory. Galileo said he "found less difficulty in the discovery of the motion of the planets, in spite of their amazing distances, than in his investigation of the flow of the water in rivers, which took place before his very eyes." It would be of considerable interest to know what the ancient philosopher and mathematician would say had he had placed upon him the responsibility of determining mathematically the capacity of the Cuyahoga River channel as it exists today.

RAINFALL AND FLOOD RUNOFF

Observations were made with a current meter at the Center St. bridge and at the Jefferson St. bridge, the



CURVE OF RAINFALL RATE AT CLEVELAND,
MAR. 23-25, 1913

distance between these bridges being about 3 mi. Three readings were taken at each location, one at the center and two midway between center and either dock. Assuming that the average velocity throughout the entire cross-section was 87½% of the average of these three readings, it is calculated that the runoff per square mile when the flood was at its maximum height was about 45 cu.ft. per sec. per square mile. The runoff cannot be determined with absolute accuracy for the reason that the cross-section of the channel when the water was high can only be approximated.

According to the rain gage of the U. S. Weather Bureau at Cleveland, rain began falling about 11 a.m. Mar. 23, and up to 8 p.m. 1.95 in. had fallen, the maximum rate being 0.35 in. per hour, which maximum rate lasted for about one hour. From 8 p.m. until 6:30 a.m. of the 24th there was no rain, but from 6:30 a.m. of the 24th until 11 a.m. 0.36 in. fell. The storm began again about 2 p.m., and ended at 10 a.m. on the 25th, the fall for this period of 20 hours being 3 in. An analysis of the above figures indicates that the two preliminary rains, amounting to 2.31 in., saturated the ground, thereby causing the 3 in. which fell during the 20-hr. period beginning at 2 p.m. on the 24th to produce a high runoff. In about 6½ hr., beginning about 6 p.m. of the 25th, 0.82 in. rain fell, but this did not reach the outlet until after the crest of the flood had passed, and produced a rise in the river of only a few inches.

The highest water at the outlet occurred about 9 p.m. on the 25th, or about 11 hr. after the rain had subsided. If the rain was uniform over the entire Cuyahoga watershed, it is evident that it requires 11 hr. to charge the entire Cuyahoga system.

Looking into the Future

While this flood was a little higher than any flood which has occurred for thirty years, it is very probable that another such flood will occur long before the expiration of the next 30-yr. period, for the reason that an analysis of the above figures shows that the 3 in. of rain which fell from 3 p.m. of the 24th until 10 a.m. of the 25th is the portion of the rain which caused the flood. According to the rain-gage readings which have been taken in Cleveland since 1879 a rainfall of 3 in. in 20 hours is likely to occur once every 11 years. The only other condition necessary to cause high water is the thorough saturation or freezing of the ground.

The flood of Mar. 25th was merely another of Cleveland's decennial object-lessons. This case is somewhat more aggravated, however, for the reason that property values and developments in the river valley have been greatly increased since the last high-water. The total submerged area (including both developed and undeveloped property) below the Denison-Harvard Viaduct was 2470 acres. It is impossible to reduce the damage to dollars and cents, but the suspended blast furnaces, submerged railroad tracks, flooded machinery, lost lumber and other miscellaneous items of damage should create and apparently have created considerable sentiment in favor of preventing, if possible, such damage in the future.

The problem of preventing damage by high water along the Cuyahoga River in Cleveland is comparatively simple, unless it be for the matter of creating sufficient public sentiment to insure the financing. If the river is straightened from the Erie Ry. bridge to the Superior Viaduct, as recommended recently by the Cleveland River & Harbor Commission,* the channel would have a capacity sufficient to provide for the recent high-water with a factor of safety of almost two. When the upper river is straightened and deepened this factor of safety will apply to the channel as far south as the Denison-Harvard Viaduct. The estimated cost of the lower river improvement is $4,800,000. The improvement of the upper 1½ mi. of channel from the present upper limits of navigation to the Denison-Harvard Viaduct is being carried out by interested property owners.

❖

Bridge Damage on the Scioto River was described in the article of Julian Griggs in our issue of Apr. 10, 1913, p. 748. Three statements in that article should be corrected and supplemented as follows:

The Norfolk & Western Ry. bridge over the Scioto at Chillicothe did not have its channel spans destroyed, but lost its north approach.

The bridge approach of the Scioto Valley Traction Co. at Chillicothe across the river had the tracks and stringers carried away completely, but only 13 pile bents of the approach were entirely destroyed.

The county bridge at Portsmouth was entirely lost, not merely the east span. The bridge consisted of two spans 242 ft. and one span 160 ft. Apparently the pile foundations of the piers were undermined. The east abutment slid out as already stated, and part of the west abutment was destroyed.

*[This straightening was described in "Engineering News," Mar. 20, 1913, p. 593.—Ed.]

Notes from the Miami Valley

(Editorial Correspondence)

Piqua, Ohio, Apr. 17.—Some of the interurban electric lines in this part of Ohio were as badly hit by the flood as the steam railways. Probably the worst destruction occurred on the Ohio Electric Ry. between Cincinnati and Dayton. Large sections of this line are wrecked as to tracks, wiring and structures. The two lines that run from Dayton north to Piqua were little injured beyond

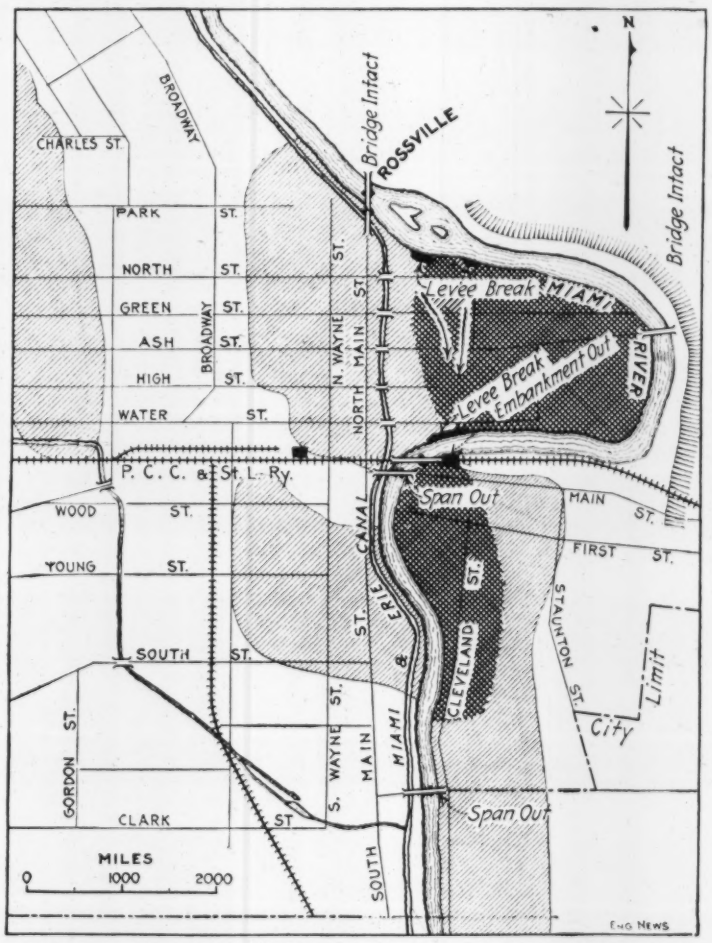


Fig. 1. Sketch Map of Piqua

(Flooded area shown single hatched. Regions of destructive currents shown double hatched. Levee and embankment breaks shown black.)

washouts of culverts and 10-ft. to 20-ft. bridges, as they are on fairly high ground all the way. Yet each of these lines had a bad washout which interrupted traffic for some little time.

The Dayton, Covington & Piqua Ry. runs up the Stillwater Valley and crosses the Stillwater by a two-span truss bridge alongside a trestle crossing of the Wellston division of the Cincinnati, Hamilton & Dayton Ry. The bridge probably was wrecked by drift. It is said a road bridge was carried down from above. The C., H. & D. trestle just below is also gone; a hundred feet of embankment at the north abutment is still there, but beyond this again a 500-ft. length of fill is out.

Work is now going on in closing the Cincinnati, Hamilton & Dayton gap by trestle. The electric line is running cars to the gap on either side and transferring passengers across on an interesting little improvised suspension bridge. Two wire ropes were slung across the piers and abutments, about 4 ft. apart, and drawn up fairly tight (5 or 6 ft. of sag), the ends being anchored to deadmen buried in the ground, and on the ropes are

cross-timbers 8 or 10 ft. apart, which support the plank flooring and handrails. The bridge seems a little flexible when a carload of passengers walks over it, but it is protected by a sign at the entrance which states that the use of the temporary bridge is at the passenger's own risk.

Piqua

At Piqua the P., C., C. & St. L. Ry. crosses the Big Miami. The river just above the bridge makes a long loop to the eastward, surrounding a straggling residence

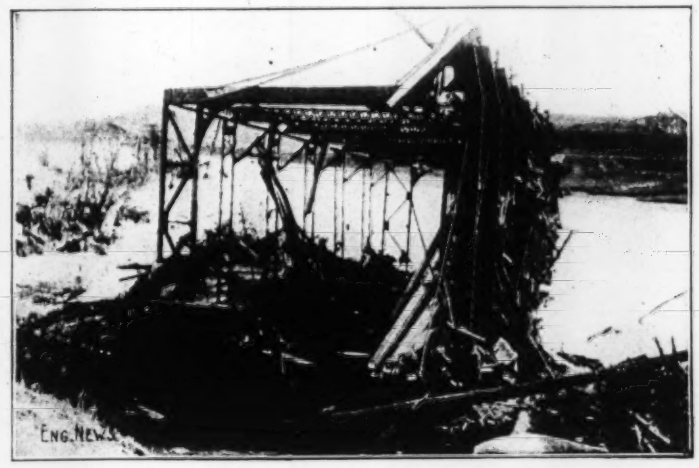


Fig. 2. A Wrecked Highway Span at Piqua, Not Much Injured by Its Fall

district. The main part of the city lies to the westward. The East Piqua section is protected by a levee on the right-hand bank of the river, extending from Rossville Bridge all around the bend to the abutment of the Panhandle bridge; see sketch map herewith (Fig. 1). The main part of Piqua lies a little higher, and is not so much exposed to overflow as East Piqua.

The Miami rose to levee height Monday evening, Mar. 24, and soon overflowed the levee along the bend around East Piqua, cutting through the levees at three places. The maximum height was reached about midnight Monday, and then the water was 4 or 5 ft. over the top of the levee, and 11.7 ft. higher than in 1898, the prior record flood. The levee washouts permitted water to short-circuit across the peninsula of low ground. Several houses were destroyed by the rapid current, or carried far off their foundations. The flood also washed out a piece of the east embankment approach of the Panhandle bridge, leaving the two through-truss spans and the abutment and pier intact, as also the new concrete piers which have been built for a new bridge at higher level (the railway is being elevated through Piqua). South of here the easterly of two spans of a street bridge was washed away, and some distance below the east span of another highway bridge. Houses on the low ground along the left-hand bank of the river between the bridges suffered considerable damage. On the sketch I have marked the sections where the current had destructive action, by crossed hatching. Some 25 to 30 persons were killed, I hear.

The river began to recede about Tuesday noon and by Thursday morning was generally off the streets. The city is supplied with water from ponds in the northwest part of the city, and the operation of the system was not interrupted at all by the overflow. The principal damage in the city was the destruction in the two outlying districts above mentioned and the general dirtying of streets and buildings and ruining of furniture, store stocks, etc.

The river at Piqua is about 300 ft. wide at the narrow points. Its depth at high water may have been about 22 to 25 ft. The elevation of high water at the southern part of the city is given as about 866, sea level datum (Albert Schroeder, City Engr.).

The crossing of the Panhandle Ry., above described, is blamed by many of the people for the flood damage, or at least for making the damage worse than it otherwise would have been. It is claimed that the two-span crossing did not provide enough waterway, and by backing up the water caused the overflow of East Piqua. As proof of the damming-up action of the railway bridge and its long east embankment approach, they point to the break of the east embankment just adjacent to the abutment. This embankment, however, had been cut into for the construction of the east abutment of the new bridge, which was to be a three-span structure, and the cut undoubtedly weakened the embankment so that it failed more easily when the water rose against it. The overflow and damage done below the Panhandle embankment also indicate that the river channel itself was entirely unable to care for the flow.

The question of the way in which obstruction of streams and valleys by bridges, railway embankment, etc., contributed to the damaging effect of the flood is a more or less general matter of discussion in the valley. All the railway crossings I have yet seen in this region provide for bridges over the actual low-water channel only and afford no channel across the river's flood plain, the approaches always being of solid fill. This is bound to have some injurious effect in a flood like that of last month, when the water covers the whole valley. But it is going to be a hard job to determine just where this condition was responsible for increased destruction; it does not seem likely that the Piqua situation is such as to put much blame on the railway embankment.

Troy

Troy, Ohio, Apr. 17—While a large part of Troy was overflowed by the Big Miami, the damage done was comparatively small. Alva W. Scott, City Engr., states that some four-fifths of the city area was covered by water. Destruction of houses took place practically only in a little outlying dwelling section north of the bend of the river, and in the southwest part of the city, resulting in a loss of about 15 lives.

Water came into the western part of the city Monday night, Mar. 24, and by 2 a.m. Tuesday the river stood as high as the canal. The water rose 3 or 4 ft. in the city between 4and 4 a.m.; the crest stage was not pasesd until Tuesday afternoon.

The city lies entirely on the valley bottom of the Miami, and there are indications that part of it occupies a former channel of the river, along the west edge of the valley. When the water got over the river bank on Monday night, Mar. 24, it started to flow right down this westerly low ground. A sketch map herewith shows the flooded area. Unfortunately the old channel (if it is such) has been completely blocked below the city by a railway embankment of the Big Four, about 10 or 15 ft. high above ground level. This has a 30-ft. opening

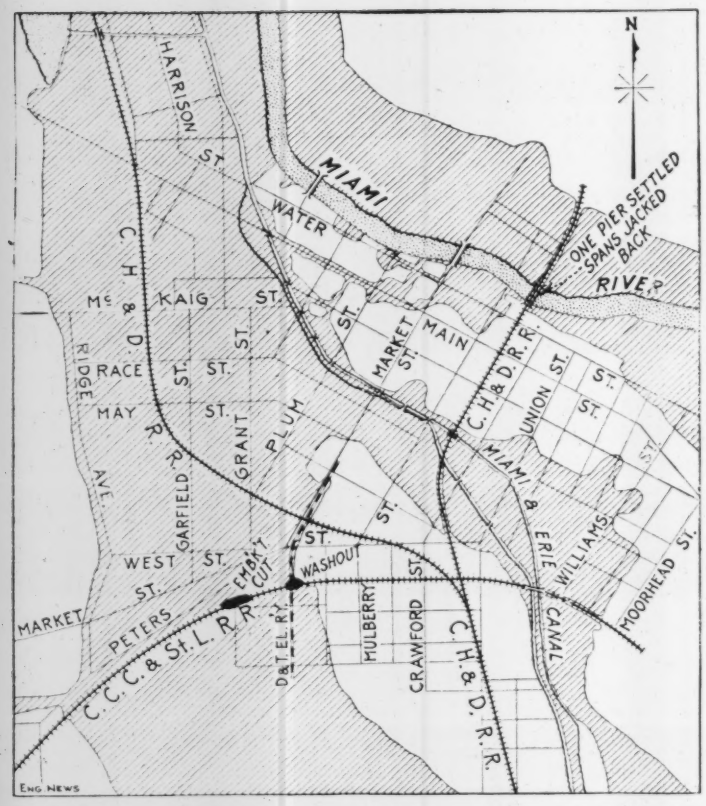


FIG. 3. MAP OF TROY, SHOWING PATH OF FLOOD WATER DOWN LOW GROUND ALONG WEST EDGE OF VALLEY

which takes the drainage from some 8000 acres of upland via the McKaig St. storm sewer, and east of this opening a short bridge over the Dayton & Troy electric railway south of the lower end of Market St. When water accumulated back of the Big Four embankment it did not find adequate discharge capacity in the two openings, and was dammed up several feet. At the crossing over the electric line the scour was so great as to undermine the east abutment and wash out some embankment east of it, leaving the tracks supported on the old fill piling. (see View A). Even this gap did not relieve the accumulation sufficiently, and the people of the neighborhood finally made a cut in the embankment a short distance west of the crossing, which soon resulted in a washout 300 or 400 ft. long.

Troy has no levees except along some farm lands. The main part of the town lies at an elevation a few feet above the westerly part, and, as the sketch plan shows, the central part was less flooded. However, it is traversed by the Miami and Erie Canal and a hydraulic race, and these, while they did not bring down a destructive water flow, made a certain amount of trouble by piling up drift and by helping to overflow the town.

No pavement was destroyed, although some unpaved streets were scoured out (at Piqua also practically no street damage was done). The work of cleaning up the streets and carrying away the house rubbish was prosecuted pretty actively, some 45 teams and 100 men being at work nearly two weeks. At this time the town looks well cleaned up.

The river dimensions and velocity, slope, etc., are not known. The elevation of high water is given as about 833, sea level.

The principal people here are strongly of the opinion that the Big Four embankment had distinct influence in contributing to the seriousness of the flood. They intend to present the facts to the Board of Army Engineers with a view to getting relief, but I do not understand just what relief is expected, whether it is to consist in a large pass through the embankment or closure of the overflow channel by a suitable levee at the upper end.

The C., H. & D. bridge in the northern part of Troy also suffered injury. This is a plate-girder through bridge of six spans, and was affected by settling of the two northerly piers, one of which is quite considerably tipped. The railway, however, managed to jack these spans back to level.

There are two highway bridges over the Miami a short distance west of this, the Market St. bridge, consisting of two steel through spans, and west of here a concrete arch bridge of three spans, recently built. Both these bridges are uninjured.

DAYTON

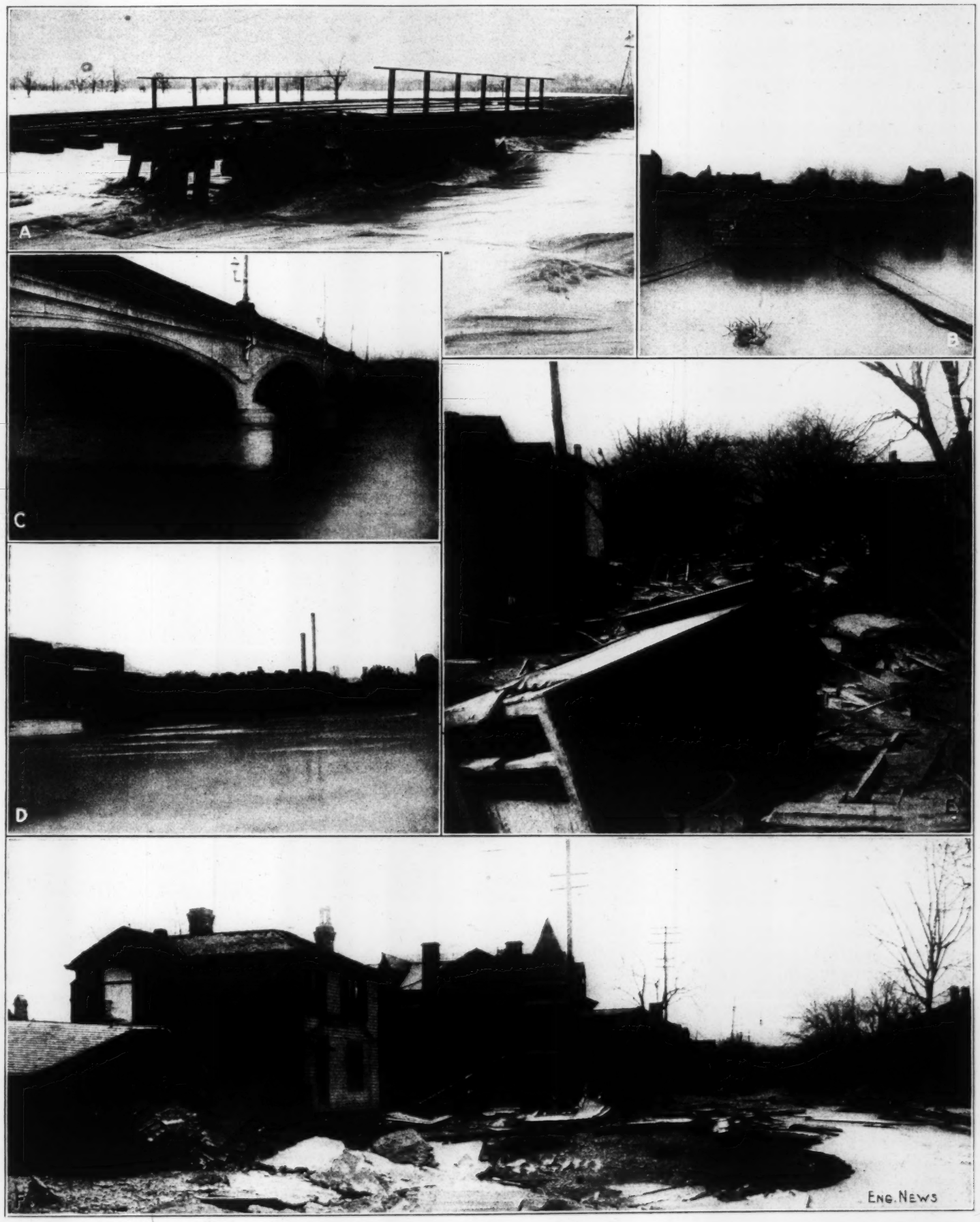
Dayton, Ohio, Apr. 19—Dayton's flood distress, which is much more severe than the Eastern newspaper reports indicate, seems to have been essentially due to submergence rather than to destruction. With the hasty notes I sent on the 15th I inclosed a sketch map showing the extent of the flooded area and marking the location of the levee washouts (ENGINEERING NEWS, Apr. 21, p. 865). The river got up to the levee top (which was nominally 3 ft. above the 1898 record-height water mark, but actually somewhat irregular) about 9 Tuesday morning, Mar. 25. The overflow quickly cut gaps in the levees, first near the upper end of the city but later also below. The middle half of the city is on the valley bottom, which is fairly well represented by the submerged area. As in the whole Miami valley, the river meanders from side to side, and the valley can be roughly outlined by drawing two lines touching the extremities of the river's bends; however, at Dayton the tributary streams make the valley rather irregular.

This valley bottom being 5 to 15 ft. below the levee tops, it is easy to imagine the effect when the water ran over the levees and started cutting crevasses through them. Where the first breaks occurred, great destruction was done; many scores of houses were washed away, wrecked or overturned, or smashed by floating objects.

It is estimated that something less than half the city's area was inundated. A more significant figure would be that representing the number of people and the number of houses directly involved in the flood, but these figures are at present subject to much guesswork. The Citizen's Relief Committee estimates that 90,000 persons were "in" the flood (total population about 120,000). H. E. Talbott, Chief Engineer to the committee, estimates that 15,000 to 20,000 buildings were in the flooded area, and from this number the magnitude of the distress produced can be judged.

The river banks are practically uninjured, except for the levee washouts and the washing and weakening of the land faces of the levees at many other points by the water overflow. The bed is probably not much scoured out, as sandbanks have again appeared above the water here and there. The scour at the time of highest water, however, must have been very great, as is shown by the washing out of some bridge piers.

The damage to the bridges is relatively slight. The city's five concrete bridges went through the flood without



A. Washout of Big Four crossing over Ohio Electric Ry., in Troy.

B. Piers of Fifth St. Bridge, Dayton, with corners ripped out.

C. Washington St. Bridge, after the flood, intact.

D. Dayton Union Ry. Bridge restored by trestling the washed-out west half.

E. Dirt and rubbish in Hanover St., Hamilton; cleaning-up work proceeding.

F. Street washout in Hamilton.

SIX VIEWS IN THE MIAMI VALLEY FROM TROY TO HAMILTON

injury, except breaking of the concrete balustrades. A number of steel bridges also passed through uninjured, (e.g., Ridge Ave. over the Stillwater, Keowee St. over the Mad, Herman Ave. over the Miami), but one railway and three highway bridges were partly wrecked, two by loss of piers and two by pushing off of the superstructure. All the bridges had water flowing over the decks.

The Helena St. bridge over the Miami just below the mouth of the Stillwater, a light highway bridge leading to an amusement park, had two spans of four carried away, and the pier supporting these two spans is gone, which might indicate that the washing out of this pier caused the spans to fall. A single-span bridge over the Stillwater at Ridge Ave., a half mile above, is intact, though water flowed over its floor. About the same distance below is the Herman Ave. bridge of five through-truss spans, near which a severe levee washout took place on the east bank, which was responsible for most of the damage in North Dayton. The bridge was subjected to a current strong enough to bend a section of both railings flat downstream, but no other damage is apparent.

The Webster St. bridge over the Mad River and nearest its mouth, consisting of two through-truss spans, was carried out, though the pier and abutments remain in slightly damaged condition. The curious thing about this is that an old single-span bridge a short distance above at Keowee St. is intact, though it has very much less waterway than the two spans at Webster St. The street bridges over the Miami in Dayton below this point are at Main St., Monument Ave. and Third St. (reinforced-concrete arch bridges of six or seven spans of 60 to 80 ft. each), Fifth St. bridge (a steel through-truss bridge whose three spans were carried off their piers), and Washington and Stewart St. (concrete arch bridges like the upper three). All five concrete arch bridges are uninjured, except for railing damage.

The most notable bridge failure in Dayton is that of the Dayton Union Ry. bridge, whose destruction cut off three railways entering from the south (Panhandle, Big Four and C., H. & D.). It was a modern deck plate-girder bridge of six spans, the three westerly of which went out. One pier is washed away and one is badly tilted. One span, intact, was carried 300 ft. downstream and lodged against the west levee, causing it to scour out part way. The failure of the bridge is possibly due to the fact that its piers did not go as deep as those of the city bridges.* The gap in the bridge was closed by trestle on Apr. 13, and trains run over it since Apr. 14.

The buildings which were wrecked seem to be in most cases such as were of light construction, as sheds, frame dwellings, etc. Where more substantial buildings were wrecked it is charged to special conditions. Thus, the North Dayton freight-house of the C., H. & D. Ry. was destroyed, being struck by floating houses it is said. A foundation washout which caused the collapse of part of a corner tower of the Steele High School, at the river front on Main St., is attributed to scour of the current deflected by a bronze lion.

Building inspection has covered some 1500 buildings so far, but this is not all of those damaged. Probably 500 of these were found seriously damaged. Only a small number of "unsafe" notices was issued.

*But Main St. Bridge, described in our issue of May 19, 1904, has its piers only 5-6 ft. below river bottom.

The department has found no evidences of settlement, except where local scour occurred. The collapse of one or two buildings during the flood (e.g., Beckel building) is supposed to be due to scour, though the causes have not been investigated. A few cases of peculiar damage were found. In the Cooper Manual Training School the swelling of the interior framing pushed out the brick walls several inches. Similar effects were found in the Colonial building, but here they are attributed to expansion of the floor boarding!

When municipal functions were resumed in Dayton, it was under martial law. But there seem to be several independent authorities. (1) The Citizen's Relief Committee, which Gov. Cox made official and which has J. H. Patterson of "Cash Register" fame at its head and H. E. Talbott as Chief Engineer, is in charge of most activities. City officials seem to be under command of this committee, and the city engineer has charge of one division of work in the engineering department. (2) The sanitary administration is independent, under Major Rhoads, U. S. Medical Corps. The local board of health works under his direction as does also the officer of the State Board of Health who was sent here; both handle assigned subdivisions of the sanitary work. (3) The Red Cross organization works independently, on the problem of helping those citizens who lost all their possessions to get a new start, by supplying trades tools, the primary elements of household equipment, etc. Also, a large squad of Red Cross nurses was assigned to health work under Major Rhoads. (4) The militia is independent, being the policing authority, and apparently in critical cases the supreme authority. (5) The State Building Inspector's office has worked on the inspection of buildings suspected of being dangerous.

The Relief Committee has exercised soverign power, backed by the militia. Men, teams, wagons, motor-cars, etc., were impressed into service. The ordinary citizen was thereby much delayed in getting goods moved, new stuff brought in, etc., and at this time the signs "We Are Open for Business" are still few enough to attract attention as you go along the street. Rigid "curfew" rules, shutting everybody indoors after 6, also made the recovery slower.

The cleaning-up problem was and is enormous. The flood water deposited several inches of soft mud everywhere. This was, at the same time, a big sanitation problem, in spite of the fact that the water and sewer services were not badly disorganized and were in service from Saturday, Mar. 29. The water system was lamed by the breaking off of many street fire-plugs, and the water-works department set to work to shut off the hydrant connections just as soon as it got the pumps started. The street-car system and some parts of the electric-light service were put in service almost as quickly. Most of the schools have been cleaned out and are running again, and a public market is just opened.

Street-cleaning has been handled very largely by wagons, though a few railway cars served by locomotive cranes handling grab buckets were employed. This method is going to be used much more extensively, it is stated.

The street dirt and rubbish has been dumped partly in vacant areas, partly into the river. Dumping platforms were built on the bridges, and the wagons drive up and

tip everything overboard. Protest was made against this a few days ago, and now the order is that only pure mud is to be dumped into the river, to avoid the chance of filling the river with débris. Rubbish and the like, other than mud, is to be burned.

Railway service started up pretty well this week, but freight movement is now hampered by congestion of the freight-houses, consignees being unable to remove their goods rapidly.

The Federal government is blamed for not taking care of the river and making it safe against flooding. It is asserted here and elsewhere in the valley that the Miami was long ago declared navigable, though I heard the contrary from Major Rand of the U. S. Engineer Office at Cincinnati. Straightening the river through Dayton is much discussed, and the Relief Committee has been considering the possibilities in this direction. The location of Dayton on the valley bottom, which has doubtless always been submerged by high floods, is not mentioned.

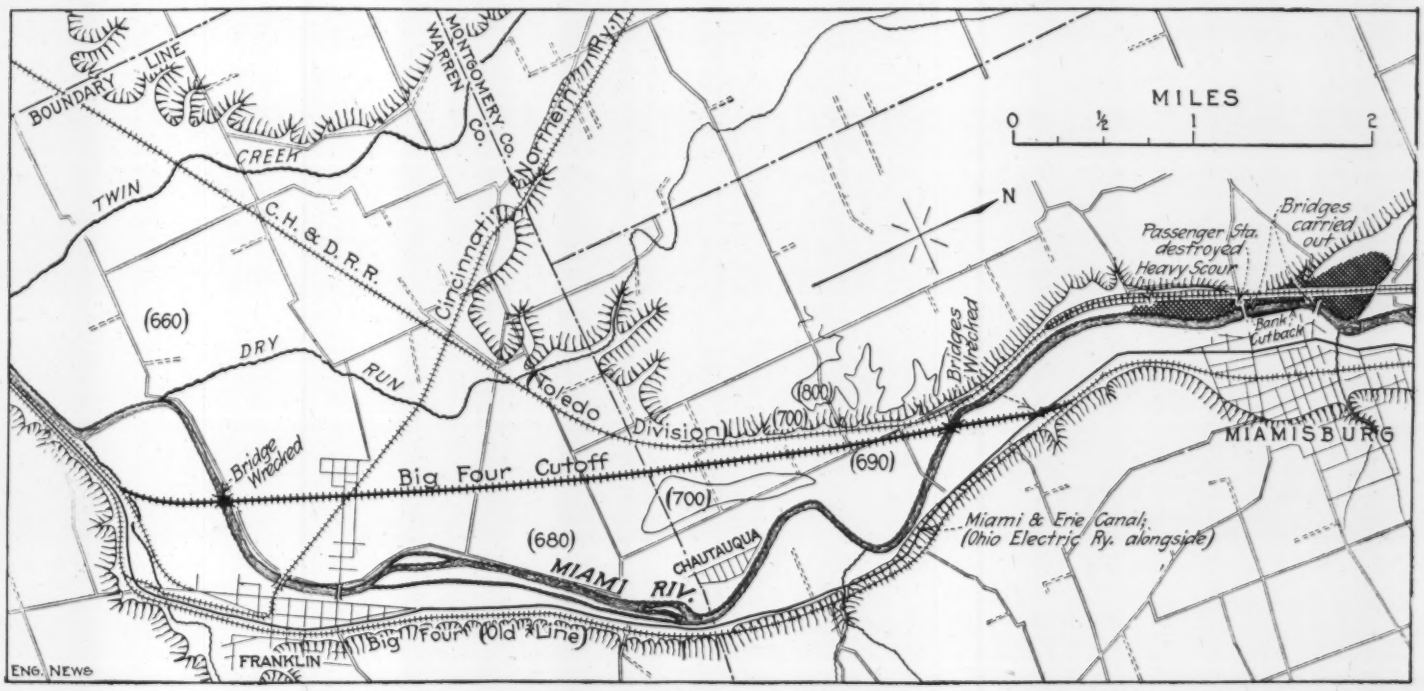


FIG. 4. VALLEY OF BIG MIAMI RIVER FROM FRANKLIN TO MIAMISBURG

(Shows approximate location of cutoff of C. C. C. & St. L. Ry. and its three wrecked bridges; and areas of damage at Miamisburg. The sides of the valley are generally of gentle slope; the hachures, at elevations 680-720, give the approximate line of the edge of the flat valley bottom.)

MIAMISBURG

Hamilton, Mar. 20—Destructive scour of the river banks occurrred 11 mi. below Dayton, at Miamisburg, in spite of the absence of bends or obstruction by embankments, etc. The location appears at the right in the sketch plan (Fig. 4). Two county bridges, each three spans of about 200 ft., were carried out; both had formerly consisted of two spans, the west span being added after the 1898 high-water, with reconstruction of the old west abutment into a pier but without excavation of the bench under the new span. The reconstructed pier of the lower bridge was undermined in the present flood, and went out of sight. The west bank was subjected to intense scour, which cut the foreshore (about 300 ft. wide) down nearly to low-water level. A twine mill near the west end of the old bridge was destroyed, and the C., H. & D. passenger station, at the lower bridge and just east of the railway embankment, was swept away. Even the freight-house west of the track was torn apart and shoved off its footings, leaving only a small piece of the building standing. About two miles of track was washed off the roadbed and the latter partly scoured away. There was even more destructive though not so extensive scour on the east bank, for 1000 ft. north of the lower bridge. The river ate into the bank, and cut it back some distance, destroying a whole row of houses and the land they stood on. The east bank was submerged back to Fifth St., east of the tracks of the Big Four. Miamisburg suffered fully as much as Dayton, both in submergence and in destruction, in proportion to its size.

The highest water here was Tuesday afternoon, Mar. 25; it stood 10 ft. 1 in. higher than the 1898 flood level. It flowed about 11 ft. deep in Main St., or about 30 ft. in the river channel. Flood flow in the Miami & Erie canal, on the east bank, carried drift which did some damage. As the canal is no longer used, the people want it filled up. Altogether ten or twelve houses in the city were destroyed, and one man drowned.

Practically no sewer or pavement damage resulted. The water-works pumps were stopped by the flood. Saturday, Mar. 29, water and electric-light service were restored.

The city was cut off from the west side and the C., H. & D. Ry. by the destruction of the two bridges. A ferry was rigged up, at the instigation of the local business people. It is a small flatboat propelled by a motor-boat hitched alongside, and is guided by pulleys running on a wire rope stretched across the river (see photo).

BIG FOUR CUTOFF

One of the most unfortunate pieces of railway destruction occured a short distance below Miamisburg, on the Big Four. Three years ago the alignment of the Cincinnati-Dayton line was straightened by a cut-off extending across a bend of the river, leaving the old line on the east bank south of Franklin and rejoining it a mile below

FIG. 5. PONTOON BRIDGE IN HAMILTON

(The only way to cross, all bridges having been carried out by the flood.

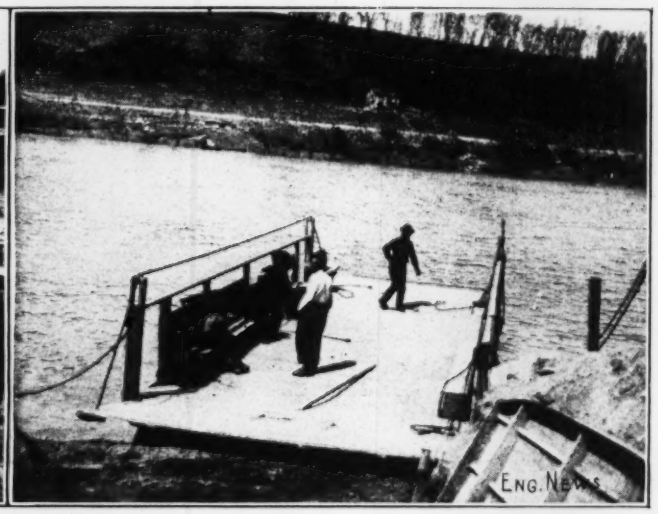


FIG. 6. EMERGENCY FERRY AT MIAMISBURG

Miamisburg. The cutoff, as roughly sketched in Fig. 4, crossed the entire river valley twice, and as it is on embankment 20 to 25 ft. high it forms two barriers across the valley, interrupted only by the two river bridges and by a bridge over the Miami & Erie Canal and the Ohio Electric Ry. at the north end of the cutoff. When the flood-flow filled the whole valley bottoms, the current was so rapid through the three openings that it scoured them out and wrecked the three bridges, besides washing off short pieces of roadbed. The cutoff was impassable, and to restore communication the railway went back to the abandoned bank location; the right-of-way, having reverted to the former owners, was secured anew, ties and rails laid, and the north end connected to the existing track by new embankment.

The three bridges were modern and of imposingly heavy appearance. The canal crossing, a skew through-truss bridge with plate-girder approach spans, was dropped by collapse of the undermined concrete abutments, and is completely ruined. The river-crossings were deck plate-girder bridges of some six or seven spans each, crossing the river on a skew; the upper one lost no spans but has several piers badly tipped, while the lower one further lost several piers and their abutting spans.

The city of Middletown fared relatively better than many other places along the river. You will be interested in two pieces of flood action, however. The forebay of a hydraulic race was cut into and the dam bypassed, leaving the risk that a flood might pass down the canal and do extensive damage; this requires emergency repair work by the state canal department. The paved causeway leading from the city to the West Middletown railway station was considerably damaged, had its river bridge carried out and much pavement destroyed; at its westerly end several houses and the railway station were wiped out. Perhaps the road tended to dam the valley and cause heavy scour through and over it.

The Ohio Electric Ry., which was very badly damaged from Miamisburg south, crosses the river valley diagonally from the southern edge of Middletown to the west bank on fill, with a river bridge and a plate-girder span over the track of the C., H. & D. Ry. Both these bridges were wrecked, and several large sections of the embankment are gone; the case reminds one somewhat of the Big Four cutoff farther upstream, as to its circumstances and the results.

The small span over the C., H. & D. Ry.* had its substantial and fine-looking concrete abutments entirely wrecked; each broke into two or three large fragments when underwashed, and these fell, with the span over them, so as to block the C., H. & D. track. Traffic on the latter was restored by hoisting the span out of the way, and laying a temporary track on sharp reverse curve winding its way through between the fallen blocks of abutment concrete. Quite a while is likely to elapse before the electric railway is again in running shape.

HAMILTON

Hamilton, Ohio, Apr. 21—Probably more destruction was done in Hamilton than in any other Miami valley city, for its size at least. The lay of the land here has a distant resemblance to that at Troy, the city being

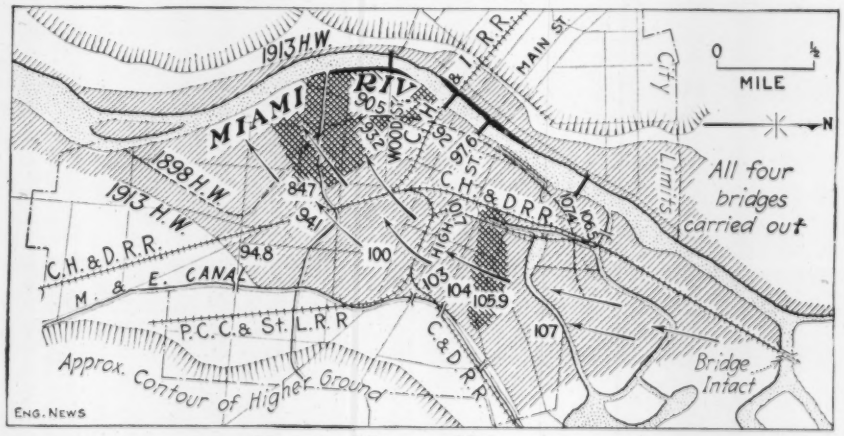


FIG. 7. MAP OF HAMILTON

(Single hatching indicates flooded area. In the double-hatched area at the bend of the river about 150 houses were destroyed by the flood currents. Much damage was done in several other areas, one of which is shown by double hatching.)

built on the flat ground inside a bend of the river. But the Hamilton situation is complicated by an old river loop above the city, and a sharp bend of the channel just above this, with a railway bridge crossing at the bend. It seems possible that in earlier times the course of the

*Illustrated in our issue of Apr. 24, p. 868.

river may have been on the inside of the present curve of the river, and south through the land now occupied by the city, along the east slope of the valley; see the accompanying sketch map (Fig. 7). People here believe that the railway bridge—the New River bridge of the C., H. & D. Ry.—was responsible for damming back the river and diverting it southward through the city. It is a fact that this plate-girder bridge, some 10 ft. deep, was overflowed about 2 ft. over the tops of the girders (and yet the piers were not undermined!). The levels which have been taken show a very steep flood slope through the city; but at the same time the river channel was full over its banks even below the railway bridge, full enough to submerge the decks of all the bridges, and rapid enough to scour out bridge piers. If the flow which went through the city had been added to the channel flow, the damage to the city might have fully as bad as what actually occurred. There was simply an unprecedented quantity of water that had to be carried off.

The crest of the flood was 10.1 ft. above the 1898 stage, which was the maximum recorded previously. (Earlier high floods were 1866, 1884, 1897 and 1898.) No estimates of the flow in cubic feet per second have been made here, so far as I can find out. The only data remotely

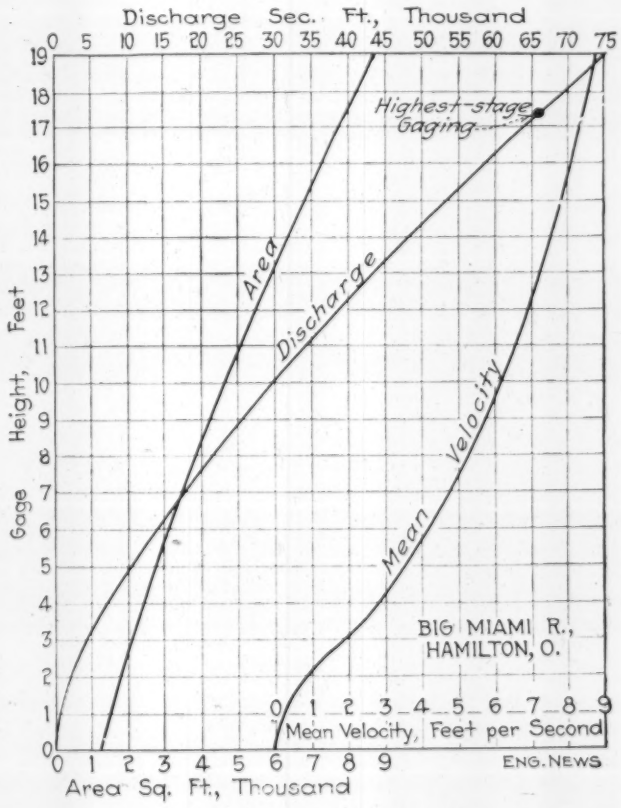

Discharge Sec. Ft., Thousand
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
Highest stage Gaging
Area
Discharge
Velocity
Mean
Gage Height, Feet
BIG MIAMI R., HAMILTON, O.
0 1 2 3 4 5 6 7 8 9
Mean Velocity, Feet per Second
0 1 2 3 4 5 6 7 8 9
Area Sq. Ft., Thousand
ENG. NEWS

FIG. 8. RATING CURVES FOR BIG MIAMI AT HAMILTON, FROM GAGINGS UP TO 17-FT. STAGE (A. H. HORTON)
(The stage reached by the 1913 flood was 33.)

bearing on the subject are some gagings made under A. H. Horton, of the Water Resources Branch, U. S. Geological Survey (Newport, Ky.). Mr. Horton furnished the accompanying plot of these gagings (Fig. 8).

Water came down Old River Tuesday morning about 10. Maximum stage was reached at 3 a.m., Wednesday, Mar. 26, and then it fell at about half the rate of rising. The river bridges went out about noon Tuesday, i.e., long before the crest of the flood. They went out in order from upstream: Black St. (city bridge), High-Main St. (one 440-ft. span; county bridge), C., H. & D.

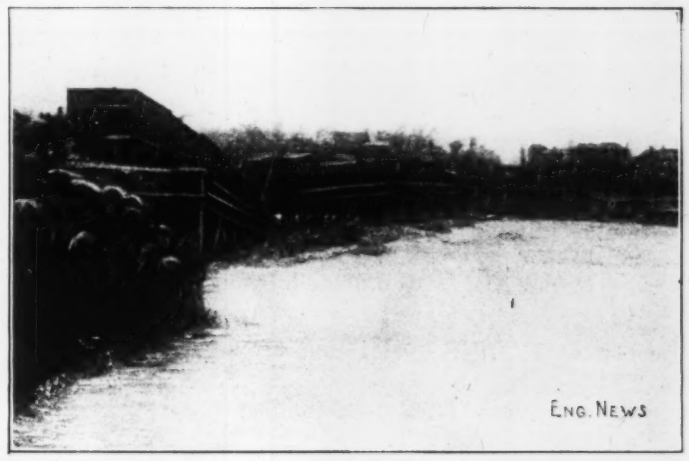


FIG. 9. FAILURE OF C., H. & D. RY. BRIDGE AT HAMILTON
(The plan of holding a bridge down by loading with freight cars, which succeeded in saving many bridges from being carried out did not protect against pier undermining.)

Ry. bridge (plate-girder spans, pier went out), and Columbia bridge (county bridge). It was necessary after the flood to operate ferries and also to build a pontoon bridge; the first pontoon bridge was torn out by a slight rise in the river after the first recession, and a stronger one was then built.

About 300 houses in Hamilton were totally destroyed, and many more damaged. Nearly a hundred lives were lost. The loss of life was equal to that at Dayton, a much larger city. Pavement was ripped up in many places. Some asphalted streets had the sheet-asphalt simply stripped off in sheets and fragments, while the concrete base was left in place uninjured. A similar action was noted in Dayton.

Sewers and the water-system were not seriously injured, but deposit in the sewers gave some trouble, and many of the sanitary sewers were clogged. Work at opening them is now going on actively. The outfall sewer at the pumping station (used in high-water periods) was destroyed, and the sanitary sewers were cut into the river for temporary discharge. The water system had its main across the river, supplying the west side, put out of service; the west side has been supplied by the Champion Coated Paper Co. since the flood. Generally, the water, sewer and electric services were in operation by Sunday, Mar. 30.

The Recent $17,600,000 Bond Election at Los Angeles.

BY BURT A. HEINLY*

The City of Los Angeles at a special election held Apr. 15, voted $2,500,000 for constructing docks and wharves and opening and improving the municipal harbor of San Pedro together with $1,500,000 for the construction of the City Trunk Line, a 76- to 64-in. pipe line, tunnel and conduit system to carry the water of the Los Angeles Aqueduct from the aqueduct outlet a distance of 25 miles into the city. These were the only issues out of a proposed total bond issue of $17,600,000 which received the necessary two-thirds vote to carry. The proposed bond issue of $6,500,000 for building a power distribution system and for the completion of the aqueduct power plant, with a capacity of 37,500 hp., for

*636 South Hill St., Los Angeles, Calif.

which $3,500,000 was voted in 1910, was defeated, as was the proposal to vote $2,000,000 for the construction of irrigation trunk lines through the Fernando Valley as a part of the plan to put 18,000 miner's inches of surplus water of the aqueduct to practical use. The Graham High Line plan for which the Board of Public Service Commissioners asked $2,500,000 as an initial expenditure to carry 11,000 miner's inches into the San Gabriel Valley was also defeated by a two to one vote. (See ENG. NEWS, Mar. 13, 1913, for the various plans for disposing of the surplus water of the Los Angeles Aqueduct).

The city trunk line, in anticipation that the people would approve of the action of the Board of Public Service Commissioners, owing to the urgency of its need, has been under construction since October, 1913, and much of the steel for the 13-mile inverted siphon across the San Fernando Valley is on the ground, funds for carrying on the work being advanced from the revenues of the water-works.

The action of the voters in refusing to authorize additional funds for power development and distribution has hampered severely the completion of this phase of the aqueduct project.

To save the work now underway on Power Plant No. 1 from deterioration, the Department of Public Service will advance up to $200,000, and six months hence the people will be asked to vote bonds for the completion of the plant and transmission lines to the city limits. Undoubtedly money for this purpose would have been voted at the election just held but there was no separation of expenditures for completion of the plant and the building of a distribution system. Over the latter subject there has been a great deal of discussion. The allied power companies of the city have made overtures for the purchase of the power and waged a most earnest campaign to defeat the bonds.

The aqueduct system will be turned over by the Board of Public Works to the Bureau of Water-Works and Supply of the Department of Public Service on May 1, but the formal dedication of the 235 miles of new system will not take place until June 17. Los Angeles is preparing for an elaborate celebration of the event at that time.

Meanwhile the vital problem of disposing of the surplus waters of the aqueduct, not only that the aqueduct may be made a financial success but also that hydro-electric energy may be developed from the plant now nearing completion, is presented to city officials. Three all-day conferences of officials have been held and while no definite program has been given out it appears to be the belief of the public press that the conference will determine, substantially if not entirely, upon the Mulholland plan of distribution.

Of other bond proposals having more than a local interest was that of $1,000,000 for the construction and equipment of an 18-mile railroad from the municipal harbor at San Pedro to the heart of the city's manufacturing district. The vote on this was: yeas, 8003; noes, 41,432. (The accompanying table at head of next column gives the votes on all the projects.)

A canvass of the vote on the foregoing described municipal enterprises might and probably will be used to give the impression that Los Angeles, foremost among the cities of the United States in undertaking enterprises along the lines of public ownership, has found them unsuccessful and is willing to return to private ownership of public utilities. Such an interpretation of the returns will be very far from correct. In almost every instance there were phases of each proposed issue quite removed from the question of municipal ownership and which were distinctly local.

RESULT OF LOS ANGELES MUNICIPAL BOND ELECTION, APRIL 13, 1913

(Two-thirds vote required to carry; deciding vote given in black-face type.)

	Yes	No
(1) $6,500,000 for completing Los Angeles Aqueduct Power Plant, bringing electric current to city and distributing same for light, heat and power	30,615	**20,800**
(2) $1,500,000 for Los Angeles City Trunk Line to bring water from end of Los Angeles Aqueduct to city for various city uses	**46,792**	4,987
(3) $2,000,000 for Chatsworth, Mission, Fernando and Glendale Irrigation Lines to convey surplus waters of Aqueduct to users outside city	21,912	**27,812**
(4) $2,500,000 for Pasadena-Glendora and San Dimas Irrigation High Line ("Graham High Line") to convey surplus Aqueduct waters to users outside city	15,835	**32,819**
(5) $2,500,000 for Harbor Improvements	**47,141**	5,390
(6) $1,000,000 for City Hall, including site	8,003	**41,432**
(7) $1,000,000 for Municipal Railroad from center of city to and around Harbor	22,935	**24,740**
(8) $600,000 for old State Normal School Site near Grand Ave., and W. 5 St., for site for municipal auditorium, art gallery, library, recreation, educational, amusement and other municipal purposes	10,248	**34,953**

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A Traction Engine Went Through a Highway Bridge across Crum Creek on the Baltimore turnpike, near Media, Md., on Apr. 20. The bridge is said to have been over 70 years old, and had been continually complained of as unsafe for automobile traffic.

The Dynamiting of a Dam in the Napanee River, near Parham, Ont., caused a flood which swept away a highway bridge below the dam and drowned a man driving in a carriage across the bridge. The parties who wrecked the dam are unknown.

A Powder Explosion in the packing house of the Atlas Powder Co., near Larding, N. J., caused the death of three workmen on Apr. 21. The three men were killed while engaged in packing shot-gun shells with black powder. It is reported that the building contained 2100 lb. of black powder.

A Ferryboat Was Swept Over a Dam across the Hudson River, at Troy, N. Y., on Apr. 24. A fog confused the pilot. About 3 ft. of water was flowing over the crest of the dam and the ferry-boat was swept over and turned upside down. Three women passengers were drowned, but four men passengers, the pilot and the owner were later rescued from an island 1500 ft. below the dam.

The Railway Accident Caused by a Derailment on the Central Vermont Ry., near St. Lambert, Que., on Apr. 13, and noted in our issue of last week, has been investigated by a coroner's jury. Testimony showed that the roadbed was in good condition and the speed of the train not excessive. The coroner's jury verdict is summarized by the Montreal "Star," as follows:

> These eight people were killed as a result of the tender being pushed in advance of the engine instead of behind the engine, but we are of the opinion that there is no crime, because, unfortunately, it is usual for this to be done, and we are of the opinion that it should never be done again.

The Proposed Schedule of Salaries for engineering employees of the City of New York (see "Engineering News," Jan. 16, 1913, p. 110), recommended by a special committee of the society known as the Municipal Engineers of the City of New York, and discussed by the society for several months, past, has been defeated by a letter ballot. The society had previously agreed that if more than 100 votes were cast against the adoption of the committee report, it should be rejected, whatever the majority vote should be. At the regular monthly meeting of the society on Apr. 23, a motion to withdraw copies of the report which had previously been furnished to the city comptroller and the Board of Estimate and Apportionment was lost.

A Mine Explosion in the Cincinnati Mine of the Monongahela River Consolidated Coal & Coke Co., at Finleyville, Penn., on Apr. 23, caused the death of from 90 to 115 men; on Apr. 26, 88 bodies had been recovered. Regarding the explosion the "Coal Age" of Apr. 26 says in part:

> This mine is located near the Town of Monongahela, about 15 miles in a straight line south of Pittsburgh. It is one of the oldest mines in the Monongahela River Valley. The Monongahela River Consolidated Coal & Coke Co. is a subsidiary of the Pittsburg Coal Co., the latter owning practically all of the preferred and 94% of the common stock of the former. The Monongahela Co. has been for the most part independently conducted, although a portion of the operating staffs of both companies is the same for economic reasons.

The mine is a drift operation and has three principal openings. Having been in operation for such a long period of time, the workings are quite extensive. It has evidently been considered dangerous from a dust and gas standpoint, reference being found in the Pennsylvania Mine Inspector's report for 1909, where the dust was being laid by a water wagon. In later reports of the Pennsylvania inspectors the mine is also rated as gaseous.

It is ventilated by an electrically driven Capell fan, which in 1911 was furnishing 129,000 cu.ft. of air per min., at a developed water gage of 3 in., the fan running at 157 r.p.m. The inspector's report for 1910 shows that the air was divided into 12 splits, but this was reduced to eight in 1911, a portion of the mine evidently having been closed off during the intervening period.

The ventilation in the mine, according to the Pennsylvania Mine Inspector's report for 1911, was considered good in some portions and fair in others. The report further states that the defects were not due to lack of adequate power, or the most advantageous arrangement of openings and airways, but rather to a lack of attention to details and over-splitting the air. It appears that brick and concrete stoppings were freely used, there having been some 70 installed during the year 1911, together with three brick overcasts. The slope at the second opening was enlarged at this same time, a 10-ton locomotive put in service, and a Morgan-Gardner longwall electric mining machine installed.

Up to the present moment, the information available as regards the cause of the explosion is meager and entirely unreliable. It was, however, evidently of great force, press reports stating that windows in buildings several hundred feet from the mine mouth were shattered and a 15-ton locomotive completely turned over. The fan house and fan were also seriously damaged, and the ventilation of the mine badly crippled. It is evident, however, that the explosion was not general throughout the entire mine, as some 70 men made their escape. From the information now at hand, most of the fatalities have been caused by afterdamp rather than by the force of the explosion itself.

The Proposed Mechanical Filtration Plant at the Jerome Park Reservoir, New York City, has been approved by an Advisory Commission of Engineers in a report to a committee of the Board of Estimate and Apportionment, of which Comptroller Wm. A. Prendergast is chairman. Bids for this plant were received by the Department of Water Supply on Jan. 23, 1913, after an eleventh-hour protest from Mr. Prendergast and the New York Bureau of Municipal Research and the Citizens' Union (see our issue of Feb. 6, 1913, p. 283). It was agreed that an award should not be made until there had been an opportunity for investigation. The commission appointed to report on the project consisted of two engineers in the employ of the city: Nicholas S. Hill, Jr., Chairman, 100 William St., and John H. Gregory, 170 Broadway; E. P. Goodrich, consulting engineer to the Borough President of Manhattan; Amos L. Schaeffer, consulting engineer to the President of the Borough of The Bronx, and John Frazee, assistant engineer, Department of Finance, New York City. The first four agree that while the filtration of Croton water is not imperative, it is highly advisable for the improvement of its physical quality and as a safeguard against potential danger. Mr. Frazee disagrees as to the present need for filtration, but agrees as to the preference for mechanical rather than slow sand filtration, and as to the reasonableness of the lowest bid. We hope to give further particulars of these reports in a later issue.

PERSONALS

Dr. W. D. Bigelow, Assistant Chief of the Bureau of Chemistry, U. S. Department of Agriculture, has resigned.

Mr. W. S. Basinger has been appointed Division Engineer of the Atchison, Topeka & Santa Fé Ry., at Chanute, Kan.

Mr. W. D. Manchester has been appointed Chief Engineer of the Manistee & North Eastern R.R., at Manistee, Mich., succeeding the late J. J. Hubbell.

Mr. L. C. Maxwell has been appointed Engineer of Maintenance-of-way of the Algoma Central & Hudson Bay Ry., with headquarters at Sault Ste. Marie, Ont.

Mr. William Mosby has been appointed Superintendent of Transportation of the St. Louis Southwestern Ry., at Tyler, Tex., succeeding Mr. F. J. Hawn, promoted.

Mr. J. W. Walter has been appointed Acting Division Engineer of the Atchison, Topeka & Santa Fé Ry. at Clovis, N. M., succeeding Mr. W. J. Lank, transferred to San Marcial, N. M.

Mr. H. L. Ingersoll, recently Assistant to the General Manager of the New York Central & Hudson River R.R., has been appointed Assistant to the Senior Vice-President, New York City.

Mr. Thomas Berry, M. Am. Soc. C. E., has become associated with Mr. Wilhelm K. Winterhalter, Consulting Engineer and Agriculturist, with offices in the Hearst Bldg., San Francisco, Calif.

Mr. H. H. Couzens, Assoc. M. Inst. E. E., formerly General Manager and Electrical Engineer of the Corporation of Hampstead, London, England, has been appointed General Manager of the Toronto, Ont., hydro-electric department.

Mr. T. R. McLeod, formerly Master Mechanic of the Halifax & Southwestern Ry., at Bridgewater, N. S., has been appointed Master Mechanic of the Canadian Northern Ontario Ry., with headquarters at Parry Sound, Ont., succeeding Mr. C. L. Webster, resigned.

Mr. Charles J. Farley, Chief Clerk of the Department of Docks and Ferries, New York City, has been appointed Deputy Commissioner of Docks and Ferries, succeeding Mr. B. F. Cresson, Jr., M. Am. Soc. C. E., resigned, as noted elsewhere in these columns. The salary of the Deputy Commissioner is $5000 per annum.

Prof. Charles E. Van Barneveld, head of the College of Mines, University of Minnesota, has been appointed Director of the Department of Mines and Metallurgy of the Panama-Pacific Exposition. Prof. Van Barneveld is a native of Holland and is a graduate of McGill University, Montreal, Que. He has been associated with the Minnesota College of Mines for the past 14 years.

Mr. Wm. B. Fuller, M. Am. Soc. C. E., Chief Engineer of the Mexican Northern Power Co., Ltd., whose capture by Mexican bandits was noted in our issue of last week, has regained his freedom by the payment of a ransom. We are informed by the office of Johnson & Fuller, Consulting Engineers, New York City, that the power company work is now proceeding uninterruptedly.

Mr. E. H. Darling, Assoc. M. Can. Soc. C. E., formerly Assistant Engineer of the Hamilton Bridge Works Co., Hamilton, Ont., has become a member of the firm of McPhie, Kelly & Darling, Architects and Engineers, Toronto, Ont. Mr. Darling is a graduate of Toronto University and for several years has been in charge of the drafting department of the Hamilton Bridge Works.

Mr. A. G. Wells, General Manager of the Atchison, Topeka & Santa Fé Ry., Coast Lines, has been granted six months' leave of absence, and Mr. I. L. Hibbard, General Superintendent, has been appointed Acting General Manager, with headquarters at Los Angeles, Calif. Mr. J. R. Hitchcock, Superintendent of the Los Angeles division, has been appointed Acting General Superintendent.

Mr. Thomas H. Johnson, M. Am. Soc. C. E., Consulting Engineer of the Pennsylvania R.R., Lines West of Pittsburgh, Penn., has been appointed Chief Engineer of the new Chartiers Southern R.R., which is to be constructed as a feeder line to the Pittsburgh, Cincinnati, Chicago & St. Louis Ry., the Pittsburgh & Lake Erie R.R. and the Baltimore & Ohio R.R. Mr. Johnson was formerly Chief Engineer of the Pittsburgh, Cincinnati, Chicago & St. Louis Ry.

Governor Elliott W. Major, of Missouri, has appointed four of the five members of the new Public Service Commission as follows: Mr. John M. Atkinson, of Doniphan, former Assistant Attorney General of the state; Mr. John Kennish, of Kansas City, a former Supreme Court justice; Prof. H. B. Shaw, Dean of the engineering department of the University of Missouri, and Mr. Frank A. Wightman, of Monett, a member of the present Railroad Commission. The salary of each commissioner is $5500 per annum.

Mr. J. R. Taft, Assoc. M. Am. Soc. C. E., formerly Superintendent of W. H. Coverdale & Co., Inc., New York City, has become a member of the firm of Emory & Eisenbrey, Civil, Chemical and Industrial Engineers, Philadelphia, Penn. A New York City office of the firm will be opened at 50 Church St., and besides the various branches of engineering work previously carried on the firm will add railway-engineering work, including reports, appraisals, preliminary and location surveys and supervision of construction.

Messrs. J. G. Jackson, Chief Engineer of the Toronto (Ont.) hydro-electric department; J. C. Smith, General Superintendent; A. G. Lang, Engineer of Distribution; A. C. McCallum, Engineer of Operation, and six other employees have been dismissed by the Mayor, following some trouble in the accounting division of the department. The ten men dismissed had previously offered their resignations in a memorial to the Mayor, protesting against the reappointment of Mr. P. W. Ellis as Chairman of the Hydro-Electric Commission, and the summary dismissal of Mr. W. R. Sweany, Acting Manager of the department.

Mr. B. F. Cresson, Jr., M. Am. Soc. C. E., has resigned as First Deputy Commissioner, Department of Docks and Ferries, City of New York. Mr. Cresson received his engineer-